

MAST STEP AND KEELSON:  
THE EARLY DEVELOPMENT OF A SHIPBUILDING TECHNOLOGY

A Thesis

by

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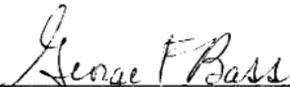
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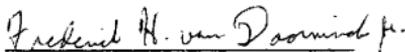
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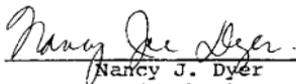
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## ABSTRACT

Mast Step and Keelson: The Early Development of a  
Shipbuilding Technology. (December 1983)

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Mediterranean mast steps and keelsons spanning the fifteen hundred years from the sixth century B.C. through the first millennium A.D. were central structural elements in a seafaring tradition whose primary vessel was the efficient merchant ship. As such, these ship timbers exhibit characteristics distinct from the Gallo-Roman tradition of inland waterway towed transport or the Scandinavian tradition of longships, designed for speed but not for commerce.

Excavated evidence from some twenty wrecks indicates that the complex of support cavities found in the mast step is likely the footing for a "boxing" arrangement which is a direct descendant of the ancient Egyptian tabernacle system.

Early examples point to the mast step being an isolated ship member, increasing in size in proportion to the enlargement in ship dimensions but remaining essentially

static in design. However, by the first centuries A.D. there developed an independent concept in the minds of ancient shipwrights, the keelson. The keelson was an integral element of the trend from shell-first to frame-first construction and the concomitant increased reliance upon skeletal support. While the "hybrid" longitudinal timber was now fastened by bolts to the keel for enhanced structural support, the need for a massive mast step, stabilized by its own weight, diminished. There had thus evolved a delicate balance between mast step and keelson whereby the two had merged quite naturally into a single longitudinal member by virtue of their identity of location.

This development of the mast step-keelson relationship mirrored the broader evolution in ship construction techniques. Careful documentation and analysis of these ship timbers will, therefore, supplement and confirm archaeologists' knowledge of the history of seafaring.

## DEDICATION

This thesis is dedicated to my wife, Gloria, and my son, Christian.

## ACKNOWLEDGMENTS

That this tribute singles out only a few of those whose inspiration and assistance have made this work possible is by no means a denigration of all the others who, through their camaraderie, made the graduate experience in nautical archaeology at Texas A&M University such a personally satisfying one. However, certain individuals have made contributions above and beyond the call of duty. To the Chairman of my Advisory Committee, Professor George F. Bass, I must not only express my personal thanks for the understanding which he has accorded to my peculiarly ambiguous approach to underwater archaeology, but I must also acknowledge the good fortune of one who can say he has learned from a true pioneer in the field. Professor Frederick van Doorninck, Committee Member, deserves credit for his substantive suggestions as well as for a "task master" demeanor which drove me to perform just that little bit better than I otherwise might have. To Professor Nancy Dyer of the Modern Languages Department, Committee Member, I am grateful for her ignoring of the advice to "never volunteer" and, accordingly, for subjecting herself to a foreign discipline with great vigor. The entire administrative staff of the nautical archaeology program deserves

mention for providing me with materials long-distance and for guiding me through the maze of university regulations.

This thesis would, not have been nearly as complete had it not been for the overly generous provision of unpublished documentation and informal comment which I received from, alphabetically, Dr. Marco Bonino; Dr. Federico Foerster Laures; Sra. Dolores Higuera; and Professor Anthony J. Parker. Their invaluable input is reflected time and again in footnotes throughout this thesis.

To my wife, Gloria, the mere dedication of this work is by no means sufficient to reflect my appreciation for the tolerance she showed in making the dream of graduate study a reality.

Finally, a special tribute must go to Professor J. Richard Steffy. Mr. Steffy is that unique individual, the envy of us all, who has transformed avocation to vocation. In so doing he has combined a world renowned expertise in ship construction with a rare human element. He is never too busy to indulge his students in what must seem to him naively elementary inquiries. His insight and guidance to me, given in numerous telephone conversations and letters, are contributions for which I cannot express enough appreciation.

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## CHAPTER I

## INTRODUCTION

A primary difficulty with interpreting ancient ships has always been the inherent unreliability of artistic representations and the ambiguity of textual references. In the case of the systems developed for planting and securing masts, or any internal ship details for that matter, even such subjective sources fail and almost total reliance must be placed on excavation results. Examination of mast steps therefore has a relative novelty about it. And perhaps that newness is the reason that detailed study of this very essence of the sailing ship has been lacking. So many questions had arisen over the decades concerning clearly depicted ship features (Mediterranean planking methods being the classic example) that initially attention turned quite naturally toward their resolution. Comment on mast steps for the most part has taken no more form than the recording of dimensions, and analysis has been relegated to terse footnotes in excavation reports. It is for these very reasons that a systematic, compara-

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This thesis employs the American Journal of Archaeology as a pattern for format and style.

tive analysis of documented mast steps is needed. For purposes of this analysis, the mast step can be defined as a longitudinal hull member resting on frames directly above the keel and housing the socket into which the foot of the mast is inserted. Ancillary to the mast step itself, but necessarily to be considered in conjunction with it, are mast partners (a deck-level support arrangement partially girdling the mast) and supportive (standing) rigging.

An additional concern is the distinction and relationship between mast step and "keelson," a longitudinal timber whose primary function is internal structural support. Did the mast step evolve into a keelson? Or, did the keelson develop as an independent concept in the minds of ancient shipwrights and merely incorporate the mast step features because they both occupied the same space?

At the outset it is necessary to distinguish three distinct early European traditions--differentiated by considerations of geography, tradition and utility. The most prominently documented have been the Mediterranean sea-going craft of the classical Greek, Roman and Byzantine eras. The Middle European tradition (encompassing examples often designated "Gallo-Roman" or "Celtic") spanning the first millennium A.D. incorporated few Medi-

terranean features into a local tradition whose chief concern was the transportation of goods by inland waterways. The craft employed were often towed barges and the mast step may, in reality, have been the footing for a towing stanchion. Finally, there was the wholly distinct northern Scandinavian heritage where sailing did not arise until the eighth century A.D.

This investigation will concern itself primarily with the Mediterranean tradition. However, any analysis of that technology must, of necessity, refer to the other two traditions, first to determine whether there may have been mutual influences and, secondly, to evaluate objectively the efficiency of the technology chosen.

An intact mast step from the Mediterranean has been dated as early as the sixth century B.C. The bulk of extant ancient examples, however, fall within the Roman imperial period from the first century B.C. through the fourth century A.D. At first glance, the design of these mast steps spanning a thousand years appears surprisingly unchanging. Perhaps that would not be so startling to some in view of the historical conservatism of the shipbuilding tradition as a whole. However, closer examination reveals subtle changes--elongating dimensions, the redesign of the notching systems, new fastening arrangements, a shift in materials. It is submitted that these changes are not arbitrary. At the very least, these

clues, taken together, reflect an increasing sophistication in the approach to this one particular aspect of sailing technology. On a grander scale, they may be indicative of undercurrents in the overall evolution of ship design as well.

The "dark ages" of the last centuries of the first millennium A.D. have yielded little excavation evidence and so it is not until the emergence of a renewed Byzantine Empire and the Italian maritime republics around the eleventh century A.D. that ship remains again appear. And by this time the transition toward a revolutionary shipbuilding technique (frame-first construction) was clearly well under way. Whether mast step technology had kept pace with this breakthrough will be significant.

As noted, only a dozen surviving mast steps are at all documented in excavation reports. Supplementation by information from archaeologists whose observations may not have been reduced to published reports will, therefore, constitute an important part of this analysis. Even ship remains without surviving mast steps may, by negative implication, prove significant. The relevance of where a mast step was not positioned may become clear in light of other aspects of the ship's construction (e.g., framing, rigging). Finally, often ambiguous textual references in contemporary authors to mast and rigging terminology will

be reviewed.

Altogether, it is hoped that the twenty to thirty documented sources presented will enable a systematic, and heretofore unattempted, consideration of the development of the mast step alone and in the greater context of the evolution of ship construction.

## CHAPTER II,

## EXCAVATED EVIDENCE

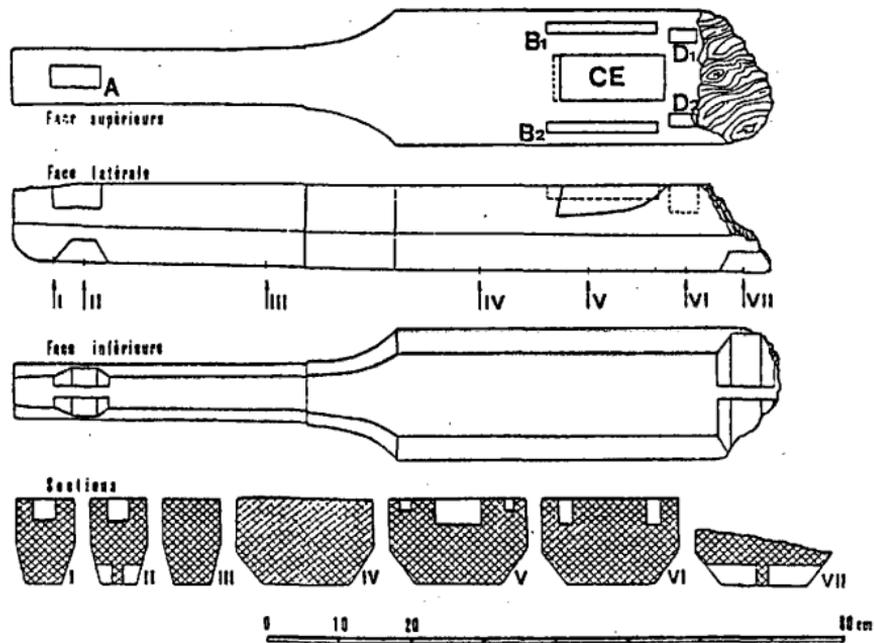
The Classical Period

The Bon Porté ship, found near St. Tropez (France) and dated to the middle of the sixth century B.C., has yielded by far the oldest identifiable ship timbers.<sup>1</sup> This small merchant vessel (ills. 1, 2 and 3) is estimated to have had a length of only 10 meters and a capacity of about 20 tons. Although only small sections of planking remained, the solidity of the ship's mast step, projected at just over one meter in length, no doubt contributed to that member's largely intact preservation. The step shows a consistent moulded dimension of 12.5 cm and a sided measurement of 8 cm for some 40 cm from the aft end, flaring at that point like a paddle to 19 cm. The timber is of a soft, white resinous wood.

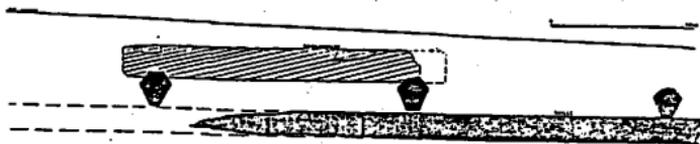
The particular value of these remains lies in the fact that they establish an early example of the simple but serviceable mast step assembly which is still seen with only

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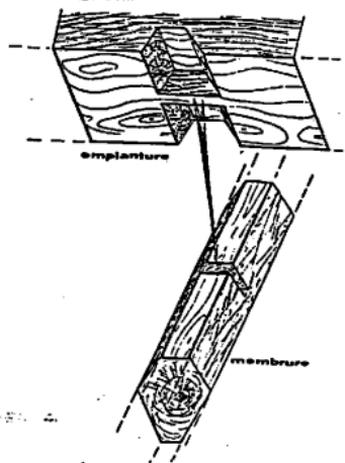
<sup>1</sup>J.-P. Joncheray, "L'épave grecque, ou étrusque, de Bon Porté," Cahiers d'archéologie subaquatique 5 (1976) 5-36; P. Pomey, "L'épave de Bon Porté et les bateaux cousus de Méditerranée," Mariner's Mirror 67 (1981) 225-44.



Ill. 1. Bon Porté Step Schematic. (J.-P. Joncheray, "L'épave grecque, ou étrusque, de Bon Porté," Cahiers d'archéologie subaquatique 5 [1976] 32)



Ill. 2. Bon Porté Step Placement. (J.-P. Joncheray,  
 "L'épave grecque, ou étrusque, de Bon Porté,"  
Cahiers d'archéologie subaquatique 5 [1976] 32)



Ill. 3. Bon Porté Step Side View. (J.-P. Joncheray,  
 "L'épave grecque, ou étrusque, de Bon Porté,"  
Cahiers d'archéologie subaquatique 5 [1976] 25)

minor modifications over 400 years later in several wrecks of the first century B.C., clear testimony to the conservatism of the shipwright and the effectiveness of the design. Here for the first time one can observe a number of features which will constantly recur in the centuries to come.

The mast step, resting on only two frames about 92 cm apart, is not fastened in any way to the keel or frames:

"L'intention du charpentier apparaît clairement, de bien caler la pièce, en l'empêchant de se déplacer d'avant en arrière grâce aux encoches, et de babord à tribord grâce aux tenons du milieu des encoches, qui correspondent, selon la schéma, à des encoches dans les membrures. Tout déplacement vertical était rendu impossible par le poids du mât... Elle est totalement dépourvue de chevilles, boulons, clous, tenons chevillés, et donc essentiellement mobile. Il est possible que, en fonction de certains impératifs, le principal étant la mise bas du mât, les marins aient eu à la déplacer, opération facile, eu égard au faible poids de l'ensemble, et à la forme évasée des encoches."<sup>2</sup>

This almost elementary reliance on notching and the weight of the mast itself to keep the step in place was obviously effective, for mast steps continue to rest on frames, unfastened, for hundreds of years.

The curvature of the main mast cavity will be seen to be another constant characteristic of mast steps. In most

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<sup>2</sup>Joncheray (supra n. 1) 34.

cases, the vertical face of the socket is toward the rear of the ship: "Le pan droit de la cavité principale vient contrebuter le pied du mât qui, certainement appuyé au niveau du pont, venait exercer à sa base une poussée vers l'arrière en raison de la force exercée par le vent dans la voilure."<sup>3</sup> Here, the back face of the cavity is not perpendicular, but is angled several degrees forward. The cavity itself is 14.5 cm long and 5.5 cm wide with a varying depth curving to a maximum of 4.5 cm at the after end.

The Bon Porté remains show an additional "locking mechanism": "Le léger écart de 1 centimetre entre la verticale et la surface d'arrêt du mât évoque un système de blocage pour éviter l'extraction du pied du mât."<sup>4</sup>

However, along with the explicable technological aspects of the mast step are found features which have thus far escaped satisfactory explanation. Two long, narrow, shallow mortises (15.5 cm long, 1.4 cm wide and 2 cm deep) to either side of the main cavity do not seem capable of a substantial support role:

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<sup>3</sup>A. Tchernia and P. Pomey, L'épave romaine de la Madrague de Giens (Var) (Campagnes 1972-1975) (Paris 1978) 98. See, also, P. Marsden, "A Boat of the Roman Period Found at Bruges, Belgium, in 1899, and Related Types," International Journal of Nautical Archaeology 5 (1976) 36.

<sup>4</sup>Joncheray (supra n. 1) 34.

"Leur faible profondeur, leur allongement n'évoquent pas un usage mécanique 'de force,' mais plutôt un emploi dans un système de réglage, plus fragile: ne pourrait-il pas y avoir coulisse des taquets ou des cales de tailles différentes, qui auraient réglé un dispositif, plus solide, de manoeuvre de pied du mât?"<sup>5</sup>

The two mortises (4 cm long and 2 cm wide), both because of their depth (4 cm) and their more extreme positions slightly forward of and out from the main cavity, appear more capable of receiving solid tenons "utiles dans un système empêchant le mât de sortir de son logement."<sup>6</sup> Some 64 cm aft of the main cavity is a mortise 7.3 cm long, 2.5 cm wide and 4 cm deep.

A late-fourth-century B.C. ship was discovered at Kyrenia, off northern Cyprus.<sup>7</sup> It was 14.7 meters long with a capacity of perhaps 30 tons. Because of meticulous attention paid to the raising and reconstruction of its timbers--unique in Mediterranean underwater archaeology--it will provide the most comprehensive ship construction analyses to date. For that reason, the craftsmanship of the mast step presents somewhat of an anomaly, in many

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<sup>5</sup>Joncheray (supra n. 1) 34.

<sup>6</sup>Joncheray (supra n. 1) 34.

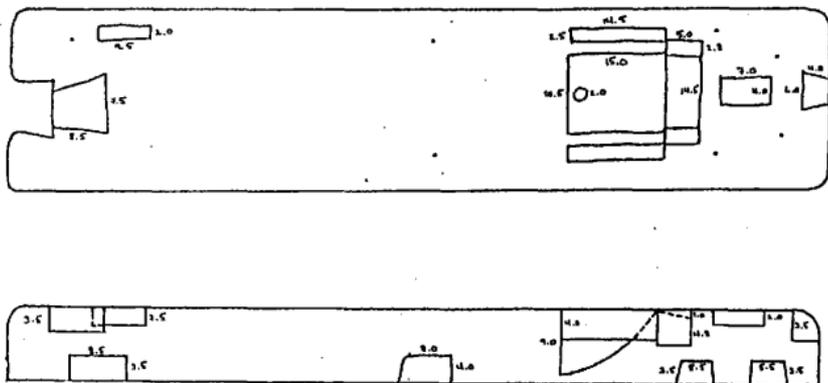
<sup>7</sup>S.W. Katzev and M.L. Katzev, "Last Harbor for the Oldest Ship," National Geographic 146, 5 (1974) 618-25.

ways representing a more advanced shipwrightery than found in the centuries which immediately followed.

The mast step of pine (ill. 4), like that of the Bon Porté ship's, is still short (just over 1.2 meters in length with a constant moulded dimension of 10 cm and sided dimension of 24 cm). However, the supporting system of mortises is as complex as that on any wreck yet excavated. In addition to the two shallow mortises (14.5 cm long, 2.5 cm wide and 4 cm deep) to either side of the main cavity, there are two deeper mortises (5 cm long, 2.8 cm wide and 4.8 cm deep). The arrangement is almost identical to that of the Bon Porté ship, but with a major exception. The Kyrenia step exhibits an inverse notching in the main cavity which will not appear again until the mid-first century B.C. Chrétienne A wreck (the Cavalière ship from early in that century does not have such a system). The Kyrenia ship's step indicates a mast raked forward at a 30° angle. Four notches for frames on the underside of the timber are so spaced that the step could have been placed in some five different positions along the ship's length.<sup>8</sup>

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<sup>8</sup>J.R. Steffy, personal communication.



Ill. 4. Kyrenia Ship Step Schematic. (After Model by J.R. Steffy)

The aft end of the step is cut out in the middle from top to bottom and there is a further trapezoidal "shelf," 8.5 cm in length, 7.5 cm wide at its forward face and 3.5 cm deep. On the upper face just forward and to the port of these carvings is a narrow mortise, 9.5 cm long, 2 cm wide and 2.5 cm deep.

Even more intriguing, this vessel has yielded the only extant remnants of the mast partner array. A stanchion step (ill. 5) was found which is 52 cm in length, 19 cm wide and 10 cm high and is notched on the forward underside to fit over a beam of some sort. From this, and a ninth to eighth century B.C. clay model from Cyprus (ill. 6), a tentative restoration of the mast partner complex has been attempted (ill. 7) by the excavators.

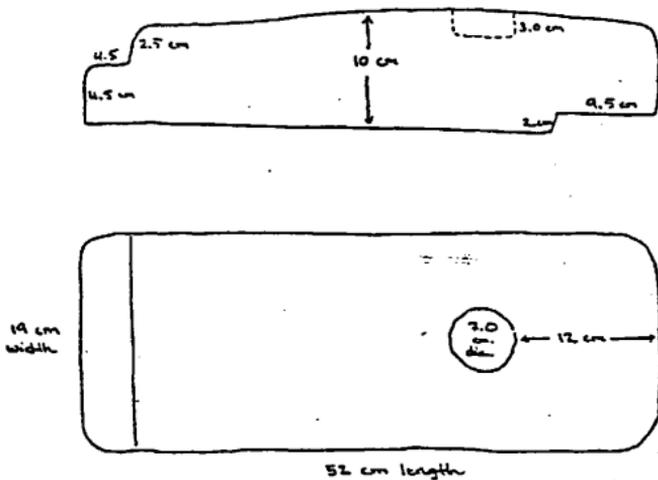
#### The Republican and Early Imperial Periods

Roman shipping during the closing years B.C. presents a somewhat consistent pattern of mast step technology, there being at most only an expectedly gradual evolution.

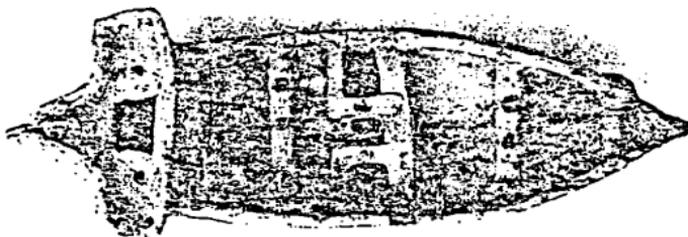
The Chrétienne C wreck (ill. 8) found off Anthéor in the 1950s has been dated to the second quarter of the second century B.C. by pottery and coin finds.<sup>9</sup> It was

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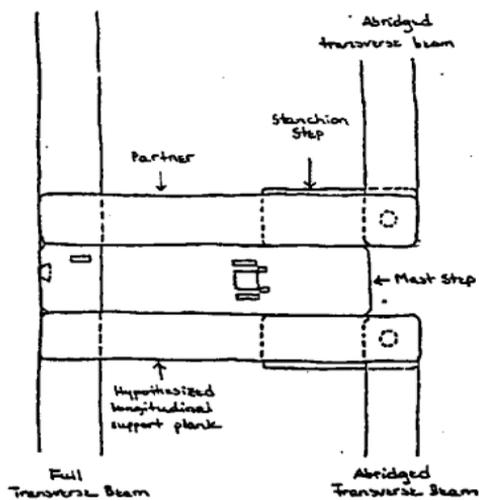
<sup>9</sup>K. Muckelroy, Archaeology Under Water (New York 1980) 52.



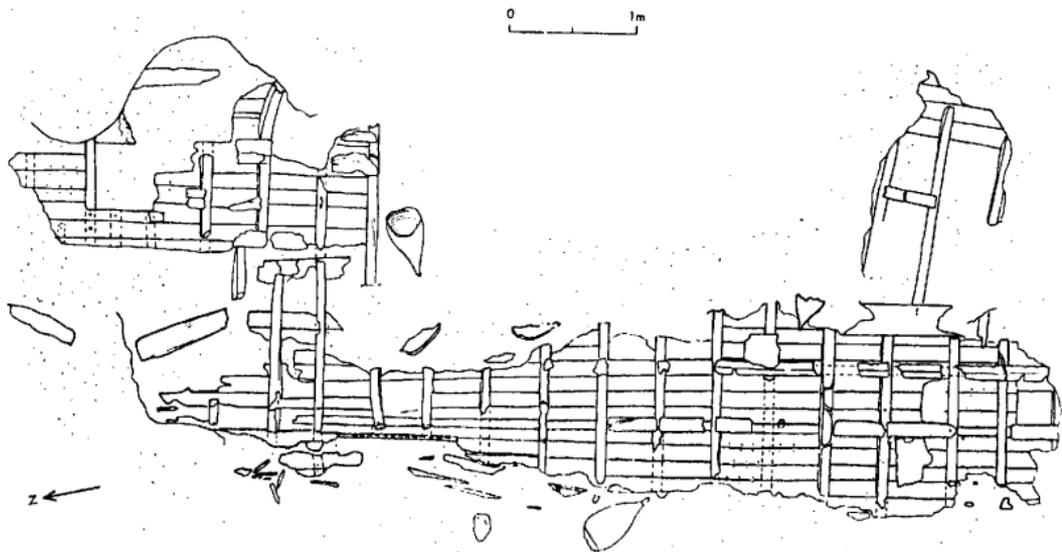
Ill. 5. Kyrenia Stanchion Step. (After Model by J. R. Steffy)



Ill. 6. 9th-8th Century B.C. Cypriote Clay Model. (Courtesy of the British Museum).



Ill. 7. Schematic Drawing of the Reconstructed Kyrenia Mast Support System.



Ill. 8. Chrétienne C Hull Schematic. (B. Liou, "Directions des recherches archéologiques sous-marines," Gallia 31 [1973] 602)

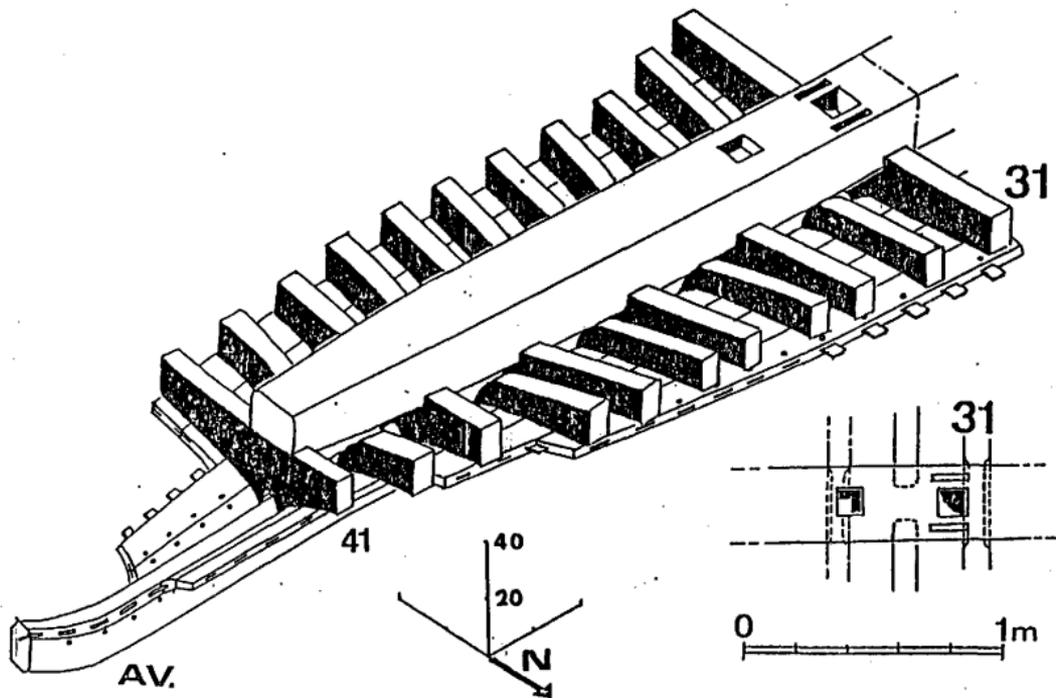
estimated at 15.5 meters in length and carried 500 amphoras. Seven meters of the keel survived together with a very deteriorated central "carling" mirroring the keel along its entire length and a lateral "stringer."<sup>10</sup>

The Cavalière wreck, a rather small 13 meter long merchantman of about 27 tons capacity from the early first century, exhibits about as simple an arrangement as possible (ills. 9,10 and 11). The step has only two long parallel mortises (14 cm long and 2.5 cm wide) one to either side of the main cavity.<sup>11</sup> Here, however, the depth of those grooves (7 cm) is almost double that of those on the Kyrenia ship for a cavity of only two-thirds the area (10.5 cm square and 7 to 9 cm deep). The mast step itself, badly eroded, has been reconstructed to a length of 7.5 meters on the basis of its imprint upon the top surface of frames. It is of Bosnian pine (pinus leucodermis). There is an alternation of frames with floors and those without in the Cavalière hull; the step is notched only to accommodate the former, which are some 27 cm apart.

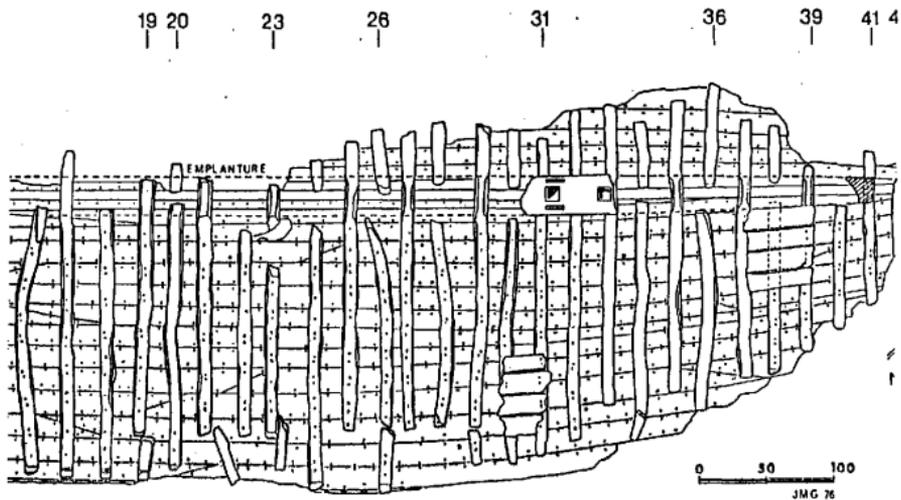
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<sup>10</sup>B. Liou, "Directions des recherches archéologiques sous-marines," Gallia 31 (1973) 603.

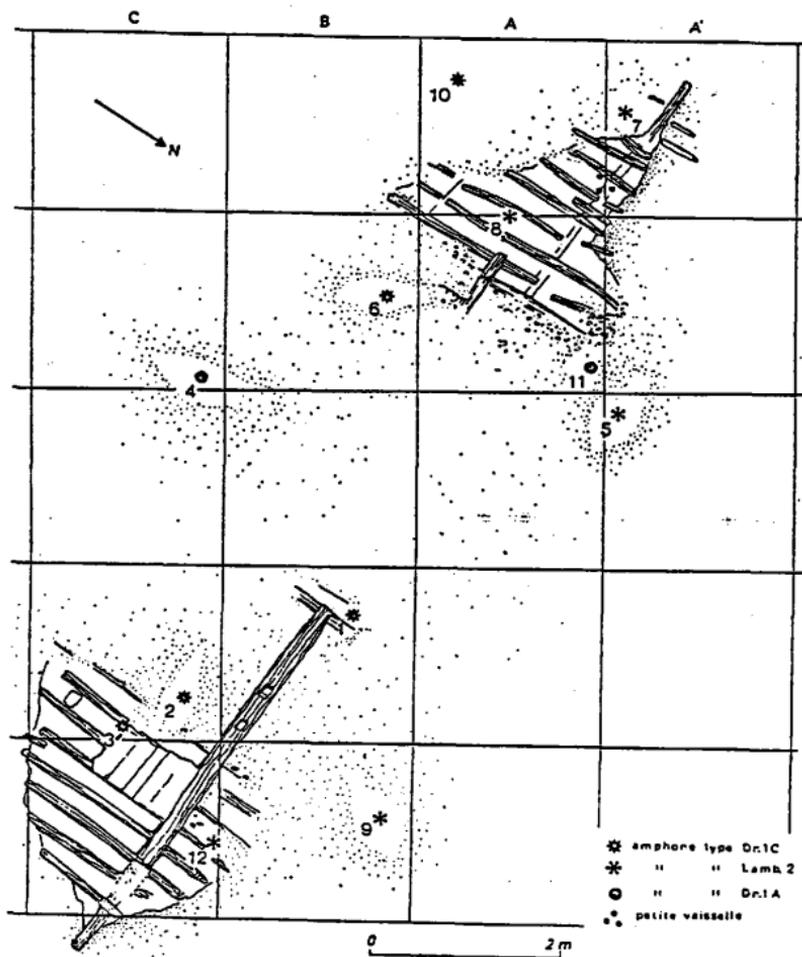
<sup>11</sup>G. Charlin, J.-M. Gassend and R. Lequément, "L'épave antique de la baie Cavalière (Le Levandou, Var)," Archaeonautica 2 (1978) 9-93; B. Liou, "Directions des recherches archéologiques sous-marines," Gallia 33 (1975) 571-605.



Ill. 9. Cavalère Step Schematic. (G. Charlin, J.-M. Gassend and R. Lequément, "L'épave antique de la baie Cavalère [Le Levandou, Var]," Archaeonautica 2 [1978] 76)



Ill. 10. Cavalière Hull Schematic. (G. Charlin, J.-M. Gassend and R. Lequement, "L'épave antique de la baie Cavalière [Le Levandou, Var]," Archaeonautica 2 [1978] fold-out)



Ill. 11. Cavalier Hull Remains. (B. Liou, "Directions des recherches archéologiques sous-marines," Gallia 33 [1975] 592)

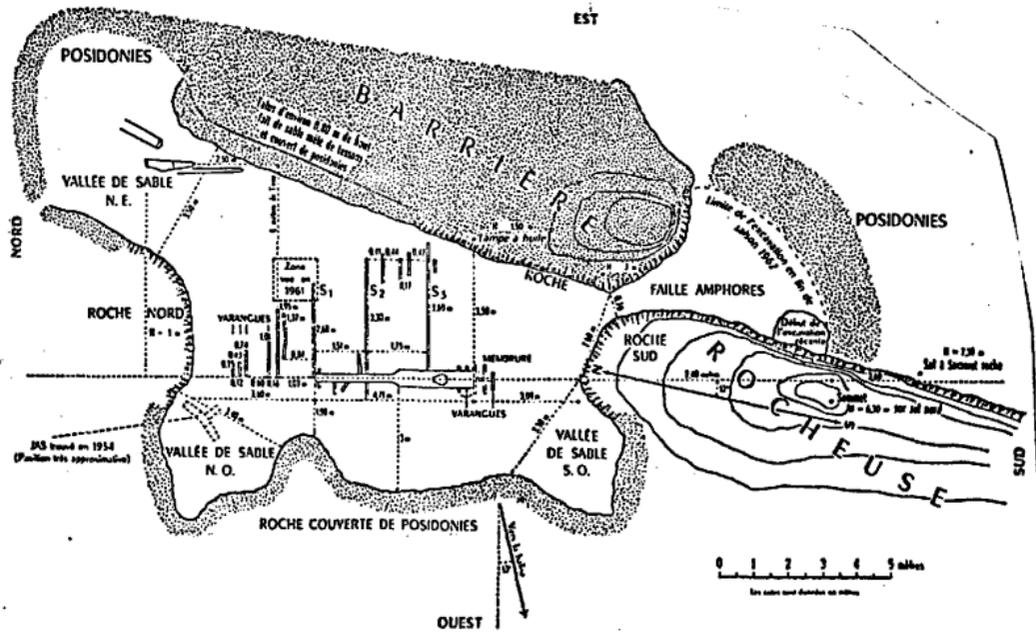
The Chrétienne A ship, also from the first century B.C., again possesses a rather simplistic step design (ills. 12, 13 and 14), but with a twist.<sup>12</sup> In this case the long, shallow parallel mortises (18 cm long, 4.5 cm wide and 4 cm deep) are cut so that they are in effect part of the main cavity. The mast here may be of significantly larger proportion as the cavity area (31 cm long, 21 cm wide with a 15.5 cm maximum depth) is six times that at Cavalière. This should not be surprising in view of the estimated length (24 to 32 meters) and capacity (200 tons) of the ship.

Another feature appears, initially, to be found for the first time. As the main cavity curves upward from the rear, before reaching the timber surface, it then curves back down to a lesser extent in the opposite direction. However, this is the reappearance of a characteristic first seen in the fourth century B.C. Kyrenia ship.

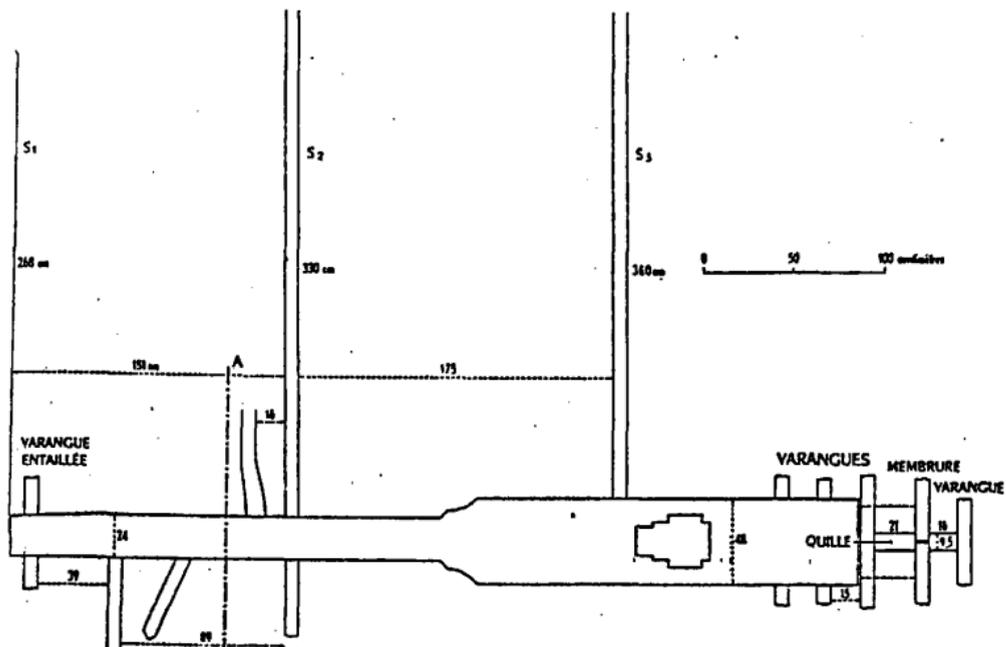
Again, the length of the mast step (hypothesized as being over 5 meters) would have acted to distribute the pressure from the mast: "cette taille était logique pour répartir les efforts du mât sur une plus grande longueur

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<sup>12</sup>F. Dumas, Épaves antiques (Paris 1964).



111. 12. Chrétienne A Hull Schematic. (F. Dumas, Épaves antiques [Paris 1964] 120)



Ill. 13. Chrétienne A Step Schematic. (F. Dumas, Épaves antiques [Paris 1964] 126-27)



de cette coque dont l'échantillonnage paraît faible pour les normes actuelles."<sup>13</sup> As at Cavalière, the step is notched to receive only underlying full floors, projected as being ten in number and spaced about 39 cm apart.

For sheer bulk, the main mast step of the mid-first century B.C. Madrague de Giens ship is unmatched.<sup>14</sup> This is quite understandable when one considers the vast size of this merchantman--possibly 43 meters in length and of 400 tons capacity. The main cavity is two-thirds again the size of that found on the Chrétienne A ship. The mast step timber, of solid oak, while only some four meters long, is massive in cross-section--55 by 45 cm, as compared with the maximum 48 by 27 cm for the Chrétienne A ship, 26 by 21 cm for that at Cavalière, 24 by 10 cm for the Kyrenia vessel and a mere 19 by 12 cm for the Bon Porté wreck. Even the later wrecks of Pointe de la Luque B and Anse Gerbal à Port Vendres are dwarfed in comparison. In view of such size, the greater depth (10 cm) found in the two, by now customary, parallel mortises along side the main cavity does not seem to indicate a greater "structural support" role. The main cavity is again "mirrored," in

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<sup>13</sup>Dumas (supra n. 12) 156.

<sup>14</sup>Tchernia and Pomey (supra n. 3).

effect, by two coupled shallow cavities of slightly different dimensions (8 cm long, 23 cm maximum width and 4.5 to 9.5 cm depth) but on the same axis, an adaptation of the reverse curvature found in the Kyrenia and Chrétienne A remains (ills. 15, 16 and 17).

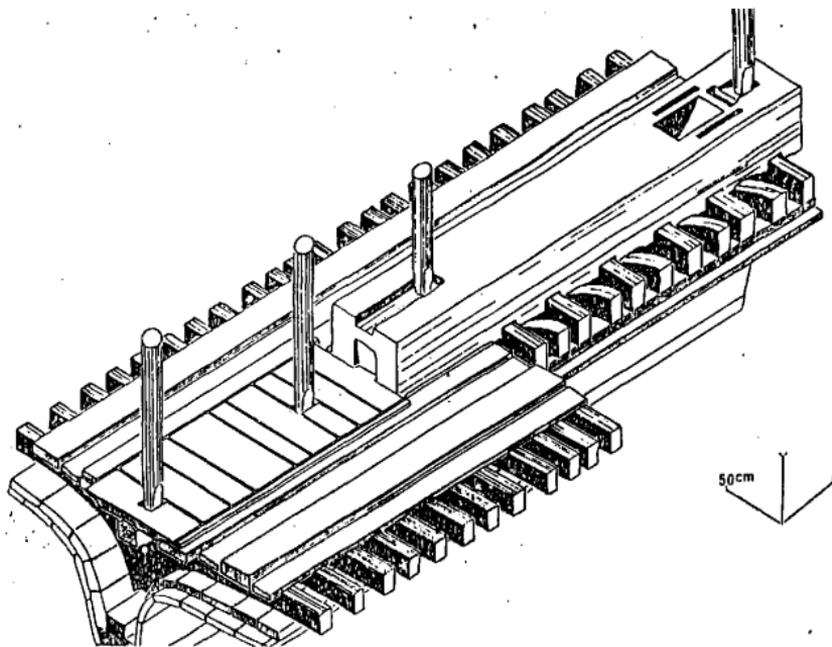
Here, again not fastened to either frames or keel, the mast step is maintained in place by its own weight and the eight notches cut in its lower face to fit floor timbers at intervals of approximately 0.5 meter. An additional bit of craftsmanship is evident in the lower edges of the timber, chamfered in the arc of a circle to permit a better fit for the half-frames (ill. 15).

An interesting footnote to the Madrague de Giens excavation has been the discovery in the 1981 season of a possible artemon mast step. A comparison of this timber with the artemon mast step on the Torre Sgarrata ship (infra) will provide valuable insight into a little known area of Roman ship design.

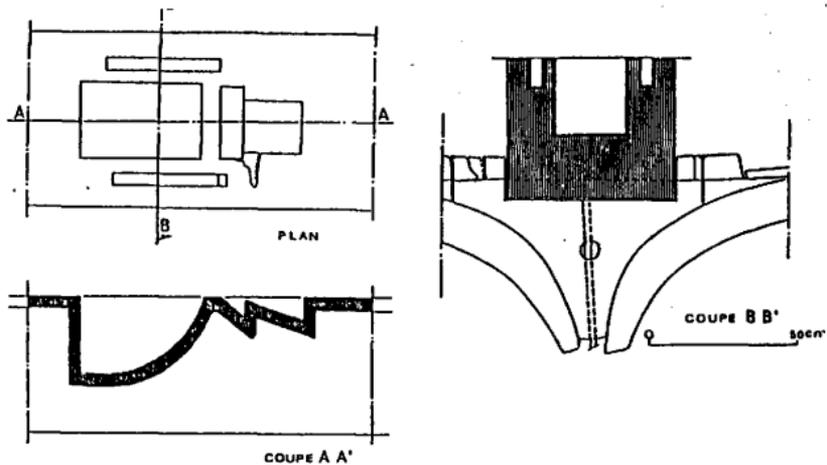
The Roman ship discovered off Cap del Volt (Spain) has provided a unique anomaly.<sup>15</sup> Dated to the final decades of the first century B.C., the hull remains permit

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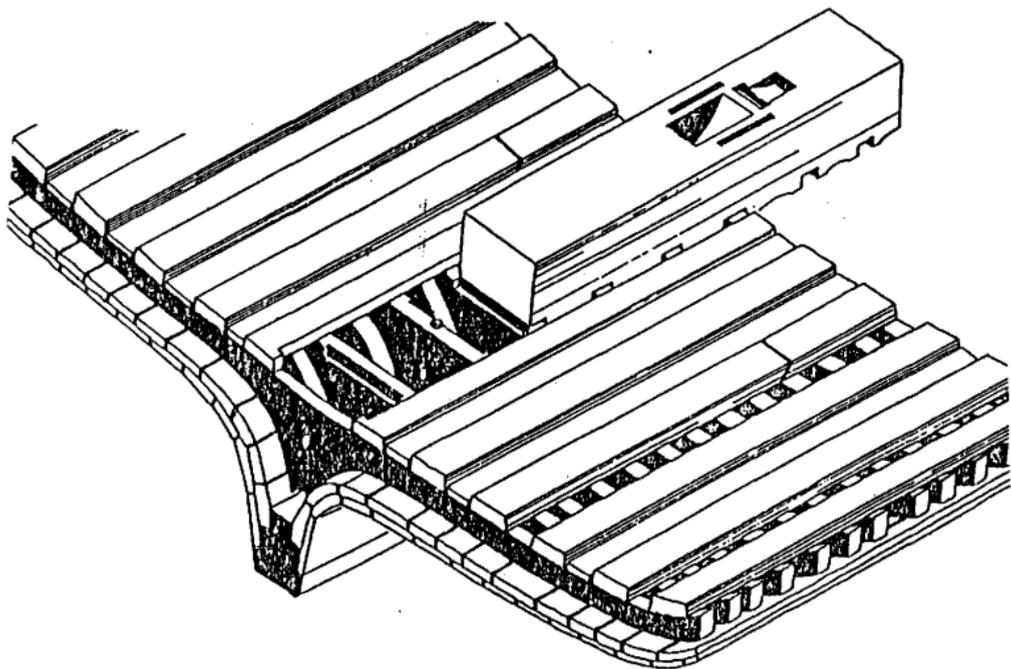
<sup>15</sup>P. Foerster, "A Roman Wreck Off Cap del Volt, Gerona, Spain," International Journal of Nautical Archaeology 9 (1980) 244-53; F. Foerster and R. Pascual, "El Pecio del Cap del Volt," Vida Submarina 5 (1982) 47-56.



Ill. 15. Madrague de Giens Step Schematic. (A. Tchernia and P. Pomey, L'épave romaine de la Madrague de Giens [Var] [Campagnes 1972-1975] [Paris 1978] plate XL)



Ill. 16. Madrague de Giens Step Sections. (A. Tchernia and P. Pomey, L'épave romaine de la Madrague de Giens [Var] [Campagnes 1972-1975] [Paris 1978] 97)



Ill. 17. Madrague de Giens Hull Schematic. (A. Tchernia and P. Pomey, L'épave romaine de la Madrague de Giens [Var] [Campagnes 1972-1975] [Paris 1978] plate XXXIX)

an estimated capacity of 50 tons, an overall length of 13 to 14 meters, a breadth of 4 to 5 meters and a depth in hold of about 2 meters. Atop the floor timbers lay, virtually intact, what the excavators have characterized as a "type of keelson."<sup>16</sup> This member (ills. 18 and 19) with an intact length of 9.2 meters, a reconstructed length of 9.5 meters and a height of 12 cm, narrows as it proceeds aft from a maximum width of 38 cm to a minimum width of 22 cm. The tapering is perhaps attributable to the use of an entire tree trunk.<sup>17</sup> The step is probably of pine (pinus abietes).<sup>18</sup>

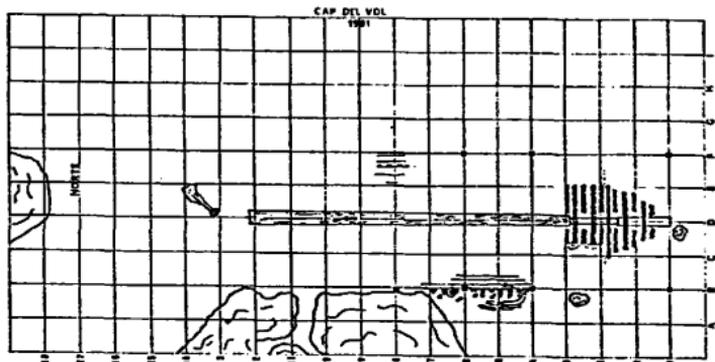
The cavity and mortise arrangement of the mast step, situated some 7.15 meters from the aft end of the timber, is again unsophisticated. A central, curved cavity (14.5 cm long and 9.5 cm wide) is flanked by two long, narrow mortises (13 cm long and 3.5 cm wide). Slightly forward is the familiar wedge cutting (4.5 cm long and 15 cm wide) with the point directed aft. A notch at the very rear end of the keelson is consistent with the placement of a mast

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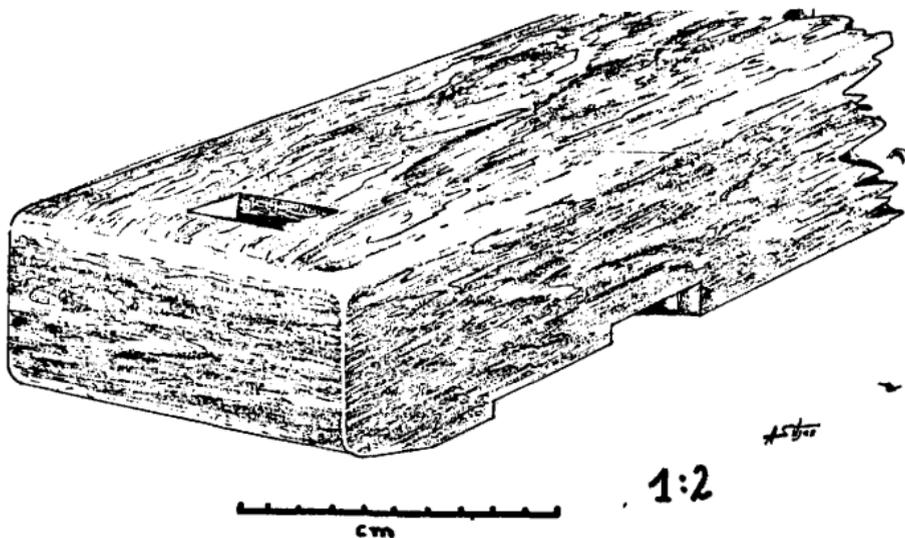
<sup>16</sup>Foerster (supra n. 15) 55.

<sup>17</sup>Foerster (supra n. 15) 55.

<sup>18</sup>F. Foerster, personal communication.



111. 18. Cap del Volt Hull Schematic. (F. Foerster and R. Pascual, "El Pecio del Cap del Volt," Vida Submarina 5 [1982] 48)



Ill. 19. Cap del Volt Mast Step Section. (Courtesy of F. Foerster, personal communication)

crutch or a deck stanchion.

The "keelson" was not fastened in any way to the keel or floors. Rather, as in earlier examples, notches were cut to fit over the floors to avoid longitudinal slipping and sideways stability was provided by ceiling planks which were nailed to the frames.

Two other mid-first century B.C. shipwrecks have given evidence of mast steps. The Dramont A wreck yielded a 1.5 meter longitudinal timber, sided 38 cm and moulded 22 cm, which was originally dubbed a "contre-quille" or "carlingue."<sup>19</sup> In retrospect, the excavators of the ship (ills. 20 and 21) have hypothesized that this segment was a step:

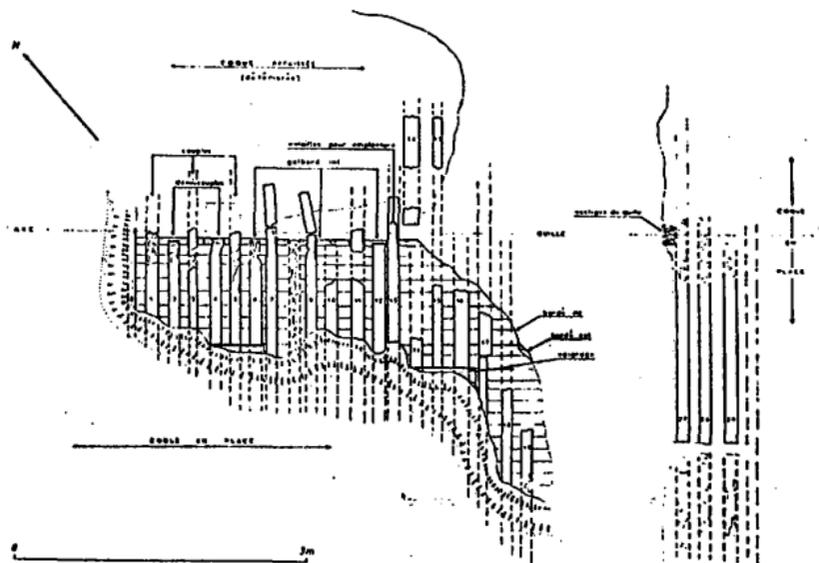
"En revanche, l'étude des entailles ménagées dans ces membrures pour caler la pièce longitudinale baptisée 'carlingue ou contre-quille' sur les schémas jusqu'ici publiés a montré que cette pièce ne saurait être en fait une carlingue doublant la quille sur toute sa longueur, mais est bien plutôt une emplanture, dont M. Santamaria évalue la longueur à 4 m environ."<sup>20</sup>

On the Dramont A vessel the "chamferring," first seen in the Madrague de Giens remains, is carried a step further

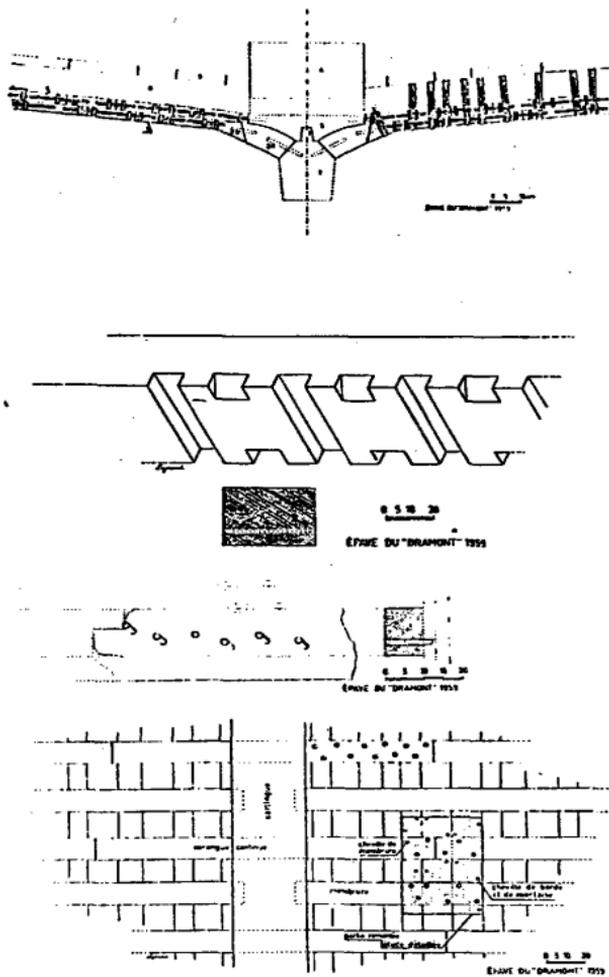
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<sup>19</sup>F. Benoit, "L'épave du Grand Congloué à Marseille," *Gallia*, Supplement XIV (1961) 143.

<sup>20</sup>B. Liou, "Directions des recherches archéologiques sous-marines," *Gallia* 31 (1973) 594. See, also, Dumas (supra n. 12) 155-56.



Ill. 20. Dramont A Hull Schematic. (B. Liou, "Directions des recherches archéologiques sous-marines," Gallia 31 [1973] 594)



Ill. 21. Dramont A Step Schematic. (F. Benoît, "L'épave du Grand Congloué à Marseille," Gallia, Supplement XIV [1961] 144)

and the underside of the mast step has full cross-notches to receive the full floors alternating with bevelled notches to fit over the half-frames angling down toward the keel. The notches are about 27 cm apart.

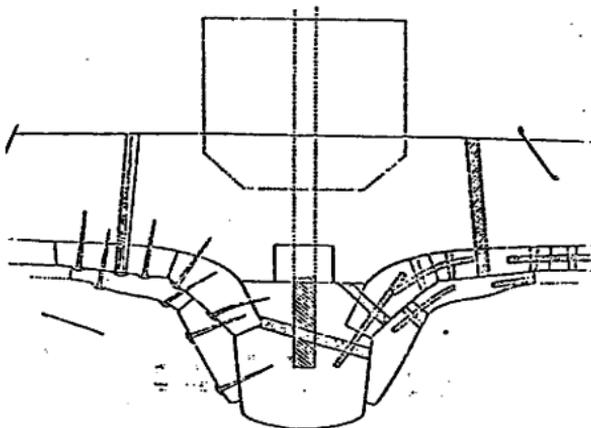
Most interestingly, the Titan wreck of the same period may show the only early example of a fastening together of the mast step, frame and keel (ill. 22 ): "Dans le cas du Titan une liaison par cheville semble avoir eu lieu...Ce serait actuellement le seul exemple connu d'une telle liaison entre le quille et l'emplature."<sup>21</sup> However, since the two treenails involved,<sup>22</sup> apparently driven from above, pass only half way into the keel, one commentator has proposed that they were intended solely for fixation of the step and not the frame.<sup>23</sup> The step on the appropriately-named Titan ship was sided 36 cm and moulded 32 cm.

The unfortunately obscurely-published wreck Île Plane à Marseille 1, dated to around 50 B.C., presents a mast

<sup>21</sup>Tchernia and Pomey (supra n. 3) 83, n. 21.

<sup>22</sup>Benoit (supra n. 19) 139.

<sup>23</sup>L. Basch, "Ancient Wrecks and the Archaeology of Ships," International Journal of Nautical Archaeology 1 (1972) 29.



Ill. 22. Titan Keel and Keelson Schematic.  
(F. Benoit; "L'épave du Grand Congloué  
à Marseille," Gallia, Supplement XIV  
[Paris 1961] 144)

step that is an "economy version" of the Madrague de Giens step with no technological evolution (ill. 23).<sup>24</sup> The step is 4.2 meters in length with a height of 22 cm and a width narrowing forward (not aft, as at Cap del Volt) from 30 to 14 cm. The main cavity is only 14 cm long, 10 cm wide and 11 cm deep. The parallel side mortises are 12 cm long and 2.5 cm wide. The inverse notch is 6 cm long, 12 cm wide and 4 cm deep. Some 12 cm forward of it lies a mortise 10 cm square and 6 cm deep, probably for receipt of a stanchion. The step lay upon seven, or possibly eight, frames approximately 0.5 meter apart.

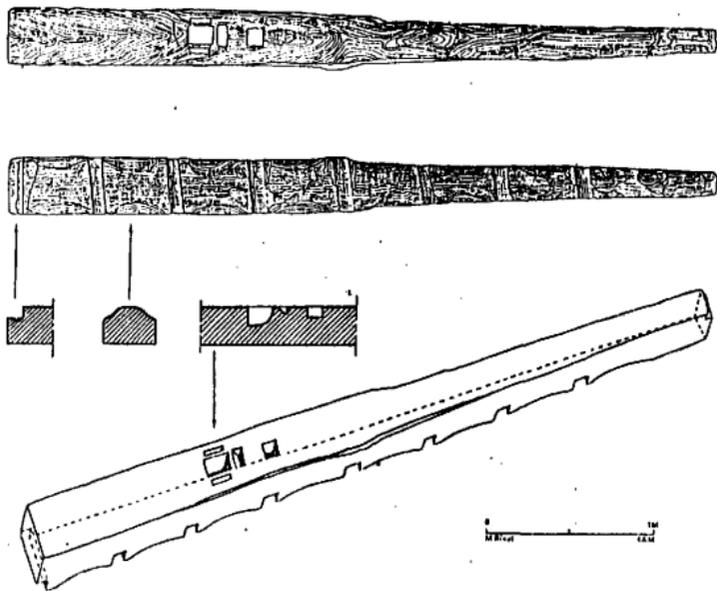
The late second century A.D. Torre Sgarrata shipwreck discovered off Taranto (Italy) has not yet received proper study, though it merits some discussion here as a footnote. Only popularly published,<sup>25</sup> its excavation provided, prior to that of the Madrague de Giens ship, the only known example of an artemon mast step (ill. 24). The description is pitifully sparse:

"The step that once supported a forward mast reveals an aspect of ancient ship construction

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<sup>24</sup>Charlin, Gassend and Lequément (supra n. 11) 76-77.

<sup>25</sup>P. Throckmorton, "Ancient Ship Yields New Facts and a Strange Cargo," National Geographic 135 (1969) 282-300; P. Throckmorton, "The Torre Sgarrata: A Late Second Century Roman Ship" (unpublished report 1968).



Ill. 23. Île Plane à Marseille 1 Step Schematic. (G. Charlin, J.-M. Gassend and R. Lequément, "L'épave antique de la baie Cavalière [Le Levandou, Var]," Archaeonautica 2 [1978] 76)



Ill. 24. Torre Sgaratta Artemon Step. (Courtesy of Kim Hart, sketch modelled after photograph in P. Throckmorton, "Ancient Ship Yields New Facts and a Strange Cargo," National Geographic 135 [1969] 290)

previously only hinted at in old floor mosaics. The Roman merchantman's fore-runner of a bowsprit carried a steering sail, or artemon, that raked forward over the bow...Rectangular socket in the elm-wood step held the heel of the mast. Stringers on timbers running the length of the ship's bottom fit into the notches cut in the...side of the step. This rare relic of Mediterranean shipbuilding is seven and a half feet long and weighs about 800 pounds."<sup>26</sup>

The details of the next two ships in chronological order are unfortunately quite sketchy.

The so-called "Caesar's galley" excavated at Marseille in 1864 has been dated to the second or third century A.D.<sup>27</sup> Only 3.8 meters remain of a hull which was originally measured at 17 meters, 7 meters of which were conserved. A section of "keelson" was sided 25 cm and moulded 20 cm and was supported on lateral "carlingues."

A Roman ship from Monaco, dated by amphoras to the third or fourth century A.D., had a "keelson," sided 9 cm and moulded 15 cm, which rested on full floors, through at least one of which a huge 40 cm long bolt of bronze was driven from beneath and riveted by a square head only

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<sup>26</sup>Throckmorton 1968 (supra n. 25) 290.

<sup>27</sup>Benoît (supra n. 16) 145. See, also, J.-M. Gassend, "Decouverte d'une épave antique," Archéologia 79 (1975) 72; C. Varoqueaux, "L'épave du Musée des Docks à Marseille," Publications universitaires des lettres et sciences humaines d'Aix-en-Provence: Etudes classiques 3 (1968-70) fig. 4.

slightly recessed into the top of the floor.<sup>28</sup> It is unclear how the "keelson" was notched for fastening, but the late date of the ship and the diagrams available point logically to a longitudinal stringer arrangement (ill. 25).

#### The Late Imperial Period

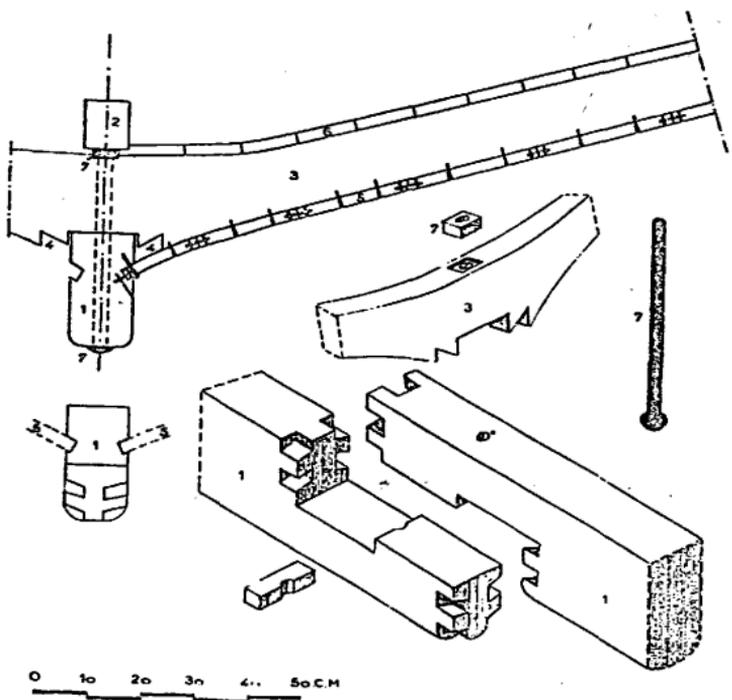
It is with the shipwrecks associated with the Late Imperial Period that the next radical technological shifts become apparent. The first basic conceptual change is that the mast step, heretofore notched onto frames, now rests on two longitudinal stringers. The lower corners of the step may be carved to accommodate these lengthwise members. The stringers, in turn, are periodically notched to fit over some (but by no means all) upraised frames. They are further nailed to all frames and in at least one instance an iron bolt transfixes the keel, frame and mast step.<sup>29</sup>

In addition, there has been a transformation in the pattern of supporting mortises. In particular, there is the disappearance altogether of the two long shallow

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<sup>28</sup>Benoit (supra n. 19) 145.

<sup>29</sup>J.-C. Negrel, "Une coque de bas-empire dans la rade de Marseille," Archéologia 55 (1973) 63.



Ill. 25. Monaco Ship Keel and Keelson Schematic.  
 (F. Benoit, "L'épave du Grand Congloué  
 à Marseille," *Gallia*, Supplement XIV  
 [Paris 1961] 146)

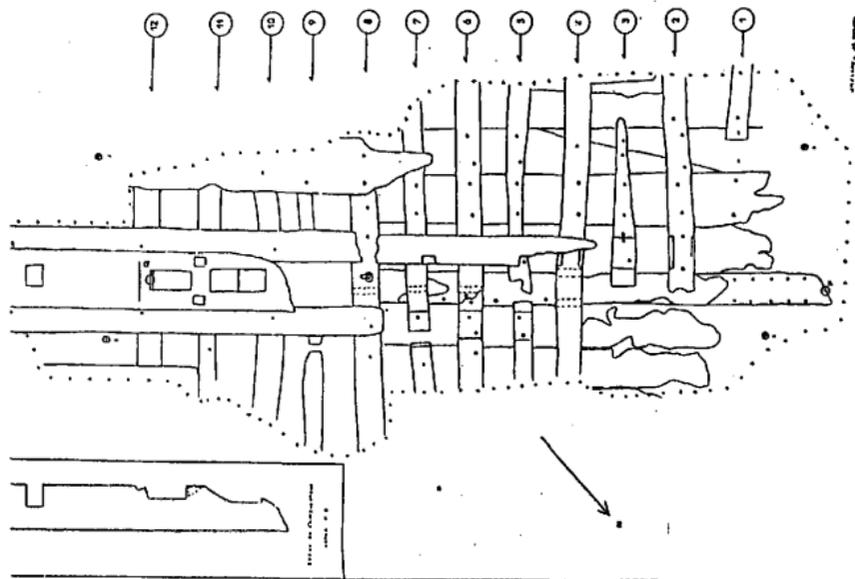
mortises parallel to the main mast socket.

The fourth century A.D. Pointe de la Luque B ship, discovered off Marseille, offers the first clear example of this evolved technology (ills. 26 and 27).<sup>30</sup> The arrangement and configuration of the cuttings in its mast step, of which only the forward 210 cm survive, is particularly puzzling. What has been taken to be the main mast cavity, with the by this period common inverse cut, has a length of 19.5 cm and a width of 7.5 cm but is only 5 to 6 cm deep. Behind the main socket are two small square holes, 6 cm long, 4 cm wide and 4.5 cm deep, tapering at a 45° angle and followed by a second deeper, longer cavity with a far more gradual inclination.

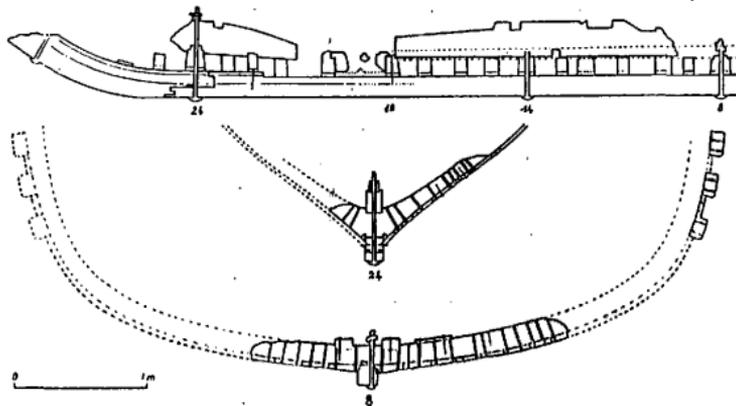
Here, for the first time, appears convincing evidence of the firm fastening of the keelson to the keel. At frame 14 (ill. 27) an iron bolt passes up from below through keel and frame into the mast step. A similar bolt appears farther aft at frame 8, although only a small piece of wood remnant remains at its tip, thought to be part of the eroded step. These fastenings would serve not only to fix

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<sup>30</sup>J.-P. Clerc and J.-C. Negrel, "Premiers résultats de la campagne de fouilles 1971 sur l'épave B de la Pointe de la Luque," Cahiers d'archéologie subaquatique 2 (1973) 61-71; J.-C. Negrel and J.-P. Clerc, "Relevé photogrammétrique d'une coque du bas empire," Cahiers d'archéologie subaquatique 2 (1973) 189-205; Negrel (supra n. 29) 59-65.



Ill. 26. Pointe de la Luque B Hull Schematic. (J.-C. Negrel, "une coque de bas-empire dans la rade de Marseille," Archeologia 55 [1973] fold-out)



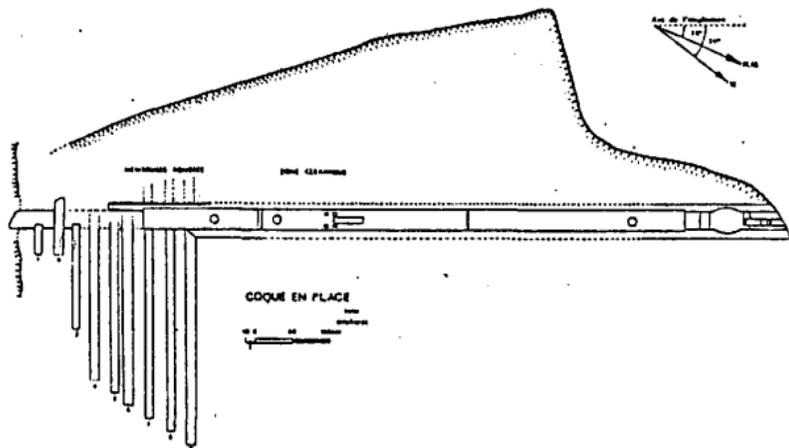
Ill. 27. Pointe de la Luque B Keel and Keelson Schematic. (B. Liou, "Directions des recherches archéologiques sous-marines," Gallia 33 [1975] 580)

the step, but also to reinforce the internal skeleton of the vessel. Further evidence at this point suggests that the mast step has begun to double as a longitudinal support structure. A previously-undocumented "carlingue" lies farther forward (frame 24), again bolted through keel, floor and "carlingue." It is clearly not a continuation of the step since the intervening surfaces of each are quite neatly sheered. It is also of slightly smaller sided and moulded dimensions. This member falls directly above the scarp joining keel and stem post and was, no doubt, meant to give added support to a potential weak point.

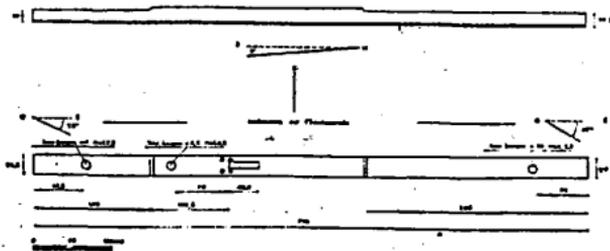
The Port Vendres A ship, dated to the late fourth century A.D., has a mast step that is confusing due to the "plastic surgery" it has undergone.<sup>31</sup> Again, one sees a fairly shallow main cavity (7.8 cm), but in this case the inverse, smaller "mirror image" cavity has been largely filled in with a nailed wedge (ills. 28, 29, 30, 31, 32). Nailed pieces of wood also fill two of the four available "support" holes. Because the mast step, over seven meters in length, was preserved so intact, three cylindrical

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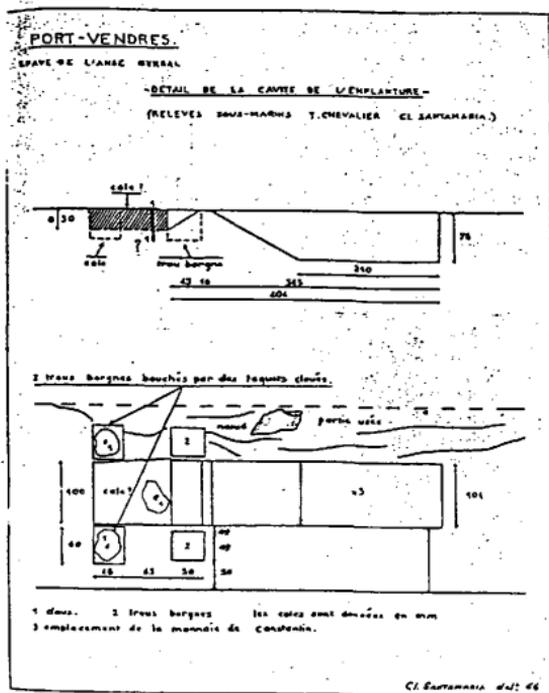
<sup>31</sup>Y. Chevalier, "La cavité d'emplanture avec monnaie de l'épave antique de l'Anse Gerbal à Port Vendres (sondages 1963)," *Revue archéologique de Narbonnaise* 1 (1968) 263-67; Y. Chevalier and C. Santamaria, "L'épave de l'Anse Gerbal à Port Vendres," *Revue d'études ligures* (1973) 7-32; B. Liou, "L'épave romaine de l'Anse Gerbal à Port Vendres," *CRAI* (1974) 414-33.



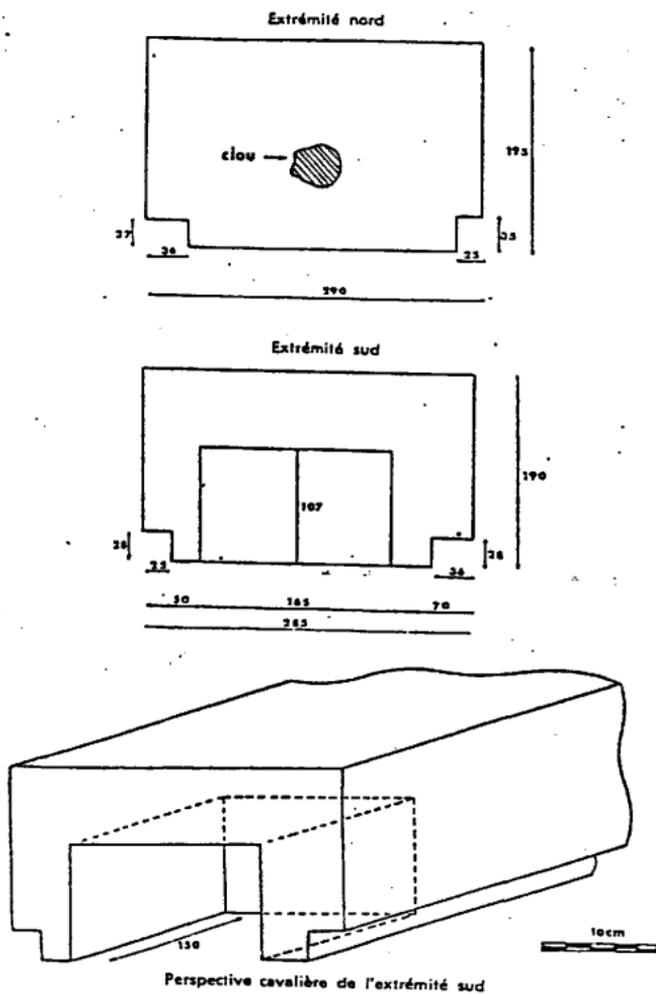
Ill. 28. Anse Gerbal à Port Vendres Hull Schematic. (Y. Chevalier and C. Santamaria, "L'épave de l'Anse Gerbal à Port Vendres," Revue d'études ligures [1973] 13)



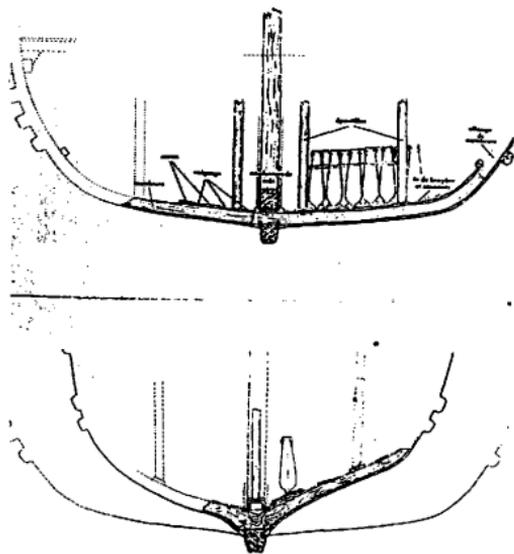
111. 29. Anse Gerbal à Port Vendres Keelson  
Schematic. (Y. Chevalier and C. Santamaria,  
"L'épave de l'Anse Gerbal à Port Vendres,"  
Revue d'études ligures [1973] 14)



Ill. 30. Anse Gerbal à Port Vendres Step Schematic.  
 (Y. Chevalier, "La cavité d'emplature  
 avec monnaie de l'Anse Gerbal à Port  
 Vendres [sondages 1963]," Revue archéolo-  
gique de Narbonnaise 1 [1968] 265)



Ill. 31. Anse Gerbal à Port Vendres Keelson Ends, Y. Chevalier and C. Santamaria, "L'épave de l'Anse Gerbal à Port Vendres," Revue d'études ligures [1973] 17)



Ill. 32. Anse Gerbal a Port Vendres Hull Schematics.  
(B. Liou, "L'épave romaine de l'Anse Gerbal à Port Vendres," CRAI [1974] 421, 430-31)

stanchion holes could be observed, two forward and one aft of the main cavity. Whether these were for stanchions supporting the deck ("épointilles") or were intended to facilitate a fastening of the step to the keel is unclear:

"Il est aussi possible que ces cavités correspondent à des logements pour des têtes de chevilles (métalliques?) , solidérisant l'emplanture à la quille (?)." <sup>32</sup>

The length of the mast step, 7.16 meters, is significant, and there is evidence that it could have been a segment in a chain of internal support. At the south, or forward, end of the member, there is a large "notch" (15 cm deep, 10.7 cm high and 16.5 cm wide; see ill. 31) which appears to be a mortise recess for a large tenon from a now-missing extension piece, perhaps an evolution from the clearly separate "carlingue" of the *Pointe de la Luque B* vessel. The northerly, or aft, end shows traces of metallic oxide, perhaps the remnant of a large nail head.

The mid-section of the mast step, starting 149 cm from the forward end, is moulded 23 cm for an interval of about 282 cm, an increase from the moulded dimension of 19 cm forward and 19.5 cm aft of this "plateau." The width of the step timber is a consistent 28 cm.

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<sup>32</sup>Chevalier and Santamaria (supra n. 31) 20.

The 19-meter-long fourth-century A.D. Yassi Ada ship has yielded no mast step or keelson.<sup>33</sup> However, by implication and tangential evidence, some estimate can be made of what such a member would have resembled. The vessel clearly represents the "new," economical approach to shipbuilding with more widely-spaced, less tightly-fitting mortise and tenon joints and a greater reliance on skeletal features. Iron bolts were employed on the Yassi Ada ship "to fasten the wale extremities to stem and stern post, and others which normally passed through every second or third frame floor were used in binding the spine to a keelson which unfortunately did not survive."<sup>34</sup>

#### The Byzantine Period

There also were no remains of a keelson on the seventh century Yassi Ada ship, a 20-meter-long vessel with a 60 ton capacity.<sup>35</sup> However, a keelson has been hypothesized

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<sup>33</sup>F.H. van Doorninck, Jr., "The 4th Century Wreck at Yassi Ada: An Interim Report on the Hull," International Journal of Nautical Archaeology 5 (1976) 115-31.

<sup>34</sup>F.H. van Doorninck, Jr., "Byzantium, Mistress of the Sea: 330-641," in G.F. Bass ed., A History of Seafaring Based on Underwater Archaeology (New York 1972) 138.

<sup>35</sup>G.F. Bass and F.H. van Doorninck, Jr., Yassi Ada, Volume I: A Seventh-Century Byzantine Shipwreck (College Station, Texas 1982).

"because of the relatively advanced stage of other internal scantling."<sup>36</sup> The keel survived from frame 11 to 28 only (ill. 33), this being approximately one-third of its projected length of 12 meters. Slotted iron bolts with washers, possibly as long as 72 cm, were driven from beneath and secured frames 11, 14, 19, 25 and 27 to the keel at intervals of 0.9, 1.6, 1.45 and 0.8 meters respectively. These slightly tapering bolts had heads ranging from 4 to 5 cm in diameter and shafts of 2 to 2.4 cm diameter. Their heads were countersunk 1 to 4 cm into the keel's under surface. The bolt length, allowing for the 35.5 cm moulded dimension of the keel and a floor of somewhat lesser measurement, might well have been sufficient to pass into, if not through, a keelson.<sup>37</sup>

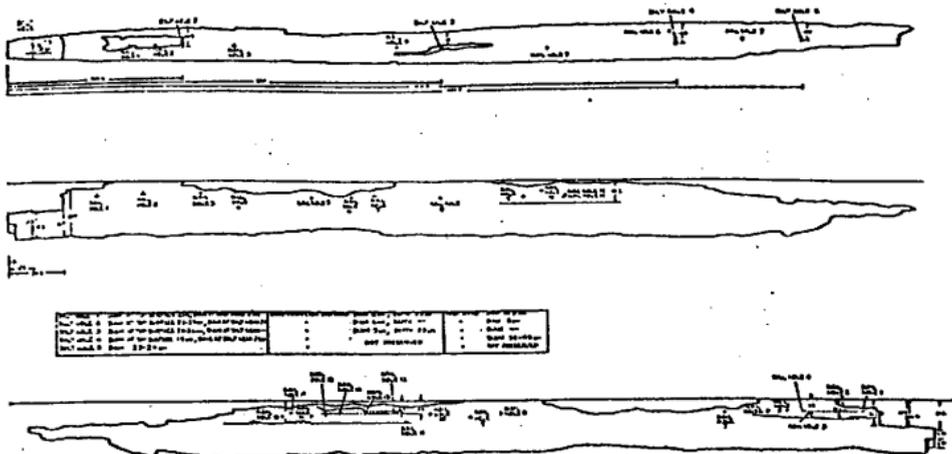
The eleventh-century Serçe Liman vessel reflects the dawn of a new age in ship construction, constituting the earliest extant example of "frame-first" construction.<sup>38</sup>

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<sup>36</sup>Bass and van Doorninck (supra n. 35) 57.

<sup>37</sup>van Doorninck notes that the only surviving "portion of frame that passed over the keel...[was] not well enough preserved to show how high the frames were above the keel" (supra n. 35) 60.

<sup>38</sup>J.R. Steffy, "The Reconstruction of the 11th Century Serçe Liman Vessel," International Journal of Nautical Archaeology 11 (1982) 13-34.

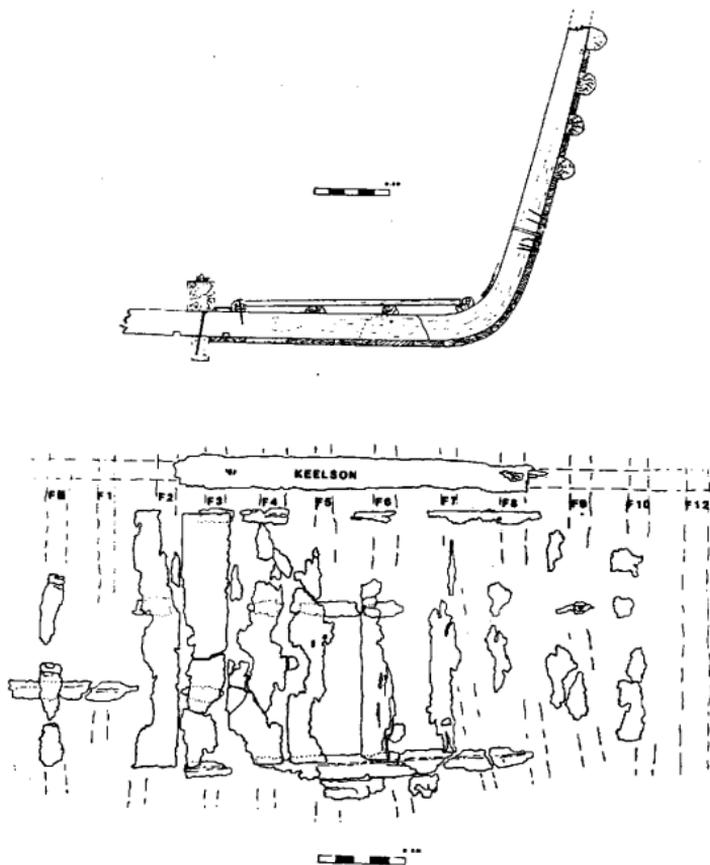


Ill. 33. Yassi Ada (seventh century) Keel Schematic. (G.F. Bass and F.H. van Doorninck, Yassi Ada, Volume I: A Seventh-Century Byzantine Shipwreck [College Station, Texas 1982] 38)

A squat ship, some 15 meters in length and 5.13 meters in breadth, it could transport 30 to 40 tons of cargo. Although the keel survived to almost its entire length (11.23 meters), only 2.17 meters of the keelson remained. It was sided 18 cm and moulded 20 cm, "having more than twice the cross-sectional area of the keel," which was sided 11 cm and moulded 16 cm. That the keelson extended the length of the ship is demonstrated by "discoloration marks on frame tops and keelson bolts running through the keel from bow to stern."<sup>39</sup> These iron forelock bolts had minimum lengths of 50 cm, shank diameters of 2.1 cm, head diameters of 3 cm and washers under the forelock keys of 3.5 cm diameter. They were positioned between the floor timbers, never through them, at intervals of 1.52, 1.48, 1.08, 1.43, 1.77 and 1.55 meters (ill. 34).

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<sup>39</sup>Steffy (supra n. 38) 20.



Ill. 34. Serçe Liman Hull Schematics. (J.R. Steffy, "The Reconstruction of the 11th Century Serçe Liman Vessel," International Journal of Nautical Archaeology 11 [1982] 22, 26)

## CHAPTER III

## FIXATION OF THE MAST

"La découverte sur plusieurs épaves, allant du VI<sup>e</sup> s. av. J.-C. au début du V<sup>e</sup> s. ap. J.-C., d'ensembles similaires, comportant tous une cavité principale à pan incliné et 3 ou 4 cavités annexes, prouve qu'un tel système n'avait rien d'exceptionnel et devait être fréquent dans l'architecture navale antique. Utilisé durant un millénaire sans subir de profondes variations, ce dispositif d'emplanture suppose, au-delà du conservatisme traditionnel de la construction navale, qu'il devait être parfaitement bien adapté à sa fonction et aux gréements en usage dans l'antiquité."<sup>40</sup>

The Mediterranean mast step complex of the Greco-Roman period truly appears as the archetypical element of constancy in ship construction. Indeed, in recognition of its importance, almost religious, or at least superstitious, overtones were attributed to it.<sup>41</sup> It is therefore ironic that such a relatively simple system has so far defied definition. That irony is rendered more under-

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<sup>40</sup> Tchernia and Pomey (supra n. 3) 96-97.

<sup>41</sup> That coins were regularly placed in the main mast step cavity for good luck is evidenced by the reports of Tchernia and Pomey (supra n. 3) 16; Chevalier (supra n. 31) 263-67; Dumas (supra n. 12) 122-23; and P. Marsden, "The Luck Coins in Ships," Mariner's Mirror 51 (1965)

standable, however, when the descriptive historical source material is reviewed.

Casson has compiled a representative listing of mast step terminology as it was employed by ancient authors.<sup>42</sup> As early as Homer, one sees reference to the literal "mast foot" itself (ἱστοπίδη [*histopedē*]). The raised nature of the timber is conveyed by the sixth century B.C. lyric poet Alcaeus' measurement of the bilge rising during a storm in terms of its relation to the mast step. The step is later alternatively described as a "trough" or a "table." The reference to a "table" perhaps provides the clue that there is another integral feature

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<sup>42</sup>L. Casson, *Ships and Seamanship in the Ancient World* (Princeton 1971) 47, 153, 233, 237. For example, *Odyssey* XII. 51-52, 161-62, 178-79, describe how Odysseus is bound to the ἱστοπίδη timber to withstand the enchanting Sirens. Alcaeus [XVIII. 6] notes: πῆρ μὲν γὰρ αὐτὸς ἱστοπίδων ἔχει --"The bilge water surrounds the mast foot." Second century A.D. Athenaeus [XI. 474-74], citing second century B.C. historian Asclepiades of Myrlea, speaks of ληνός: ἢ ἐμπέπτει εἰς τὸν ληνόν --"that part of the mast which fits into the trough." And third century B.C. historian Daimachus describes: τῆς δὲ πλοῦσης μέσον ἐπὶ τῆς τράπεζας προσαρμόζεται ἡ τράπεζα, ἣς ἐντὸς ὁ ἱστός ἱσταται "In the middle of the ship over the keel is fitted the mast step in which the mast stands.

to the scheme. This characterization is consistent with references made to both the μεσόδμη (mesodme, i.e., "built in between or in the middle") and the parastatae ("standing beside"). The mesodmai of a house, as Casson points out, "are tie-beams running from rafter to rafter; so the 'hollow mesodme' [referred to in the Odyssey] here could be a carling, running fore and aft between two thwarts amidships, that had a hole or notch in it which centered over the mast step."<sup>43</sup> A similar "girdling" function seems to have been served by the parastatae, which have been described as standing posts that support the mast.

Still, it is obvious that contemporary authors were

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<sup>43</sup>Casson (supra n. 42) 47. In Odyssey II. 424-25, Homer speaks of ἵστων ὀϊστάτινον κοίλης ἔντοσθε μισόδμης/στῆσαν αἰράντες, κατὰ δὲ προτόνοισιν ἐδήσαν-- "Raising the fir mast they set it inside the hollow 'mesodme' and fastened it down with the forestays." Cato the Elder [fr. 18] recounts: "malum deligatum, parastatae vinctae"--"The mast was made fast, the parastatae lashed," wherein "parastatae stipites sunt pares stantes quibus arbor sustinetur"--"The parastatae are a pair of standing posts that support the mast" (Isidore, Orig. XIX. 2.11).

in no way concerned with the precise niceties of ship technology. So much for the hope that this tangled web might be un-muddled from the vagueness of literary works of the day. What observations, then, can be made from the archaeological evidence outlined previously?

The central question, of course, unavoidably revolves around the series of cavities which are found on all Mediterranean ships. At the outset, this complex can be distinguished from the simple single-socket "keelson" mast setting on both Celtic and Scandinavian ships (see Chapters V and VI, *infra*). That distinction is the result of obvious conceptual differences. On Scandinavian ships the main mast support is supplied by an exaggerated deck-level mast partner with far less strength (other than the inherent resistance of the mast cavity) supplied at step level. The trade-off necessitated by that approach is noted in Chapter VI. Essentially, it is a space inefficient arrangement which is acceptable only because of the seeming lack of concern or appreciation which the early Scandinavians had for cargo capacity. Celtic ships show no sophisticated keelson-level array for a very different reason. The sail in most of these instances was not the primary means of propulsion or, at most, was intended for duty in a more moderate environment (lakes and rivers). Indeed, the majority of examples cited reflect a "step"

accommodating a towing stanchion. Consequently, there could be some sacrifice in the strength of the stanchion support resulting in increased cargo capabilities. For those instances where a sail is more likely (e.g., Blackfriars and Bruges), it can be hypothesized that some deck-level support was present.

Similarly, an explanation for the curious scheme of Mediterranean ships must be found in practicality, albeit of a different sort. And, in fact, that practicality is most likely a hybrid of the Celtic and Scandinavian concerns--for the Mediterranean shipwright was designing a vessel to meet the more stringent requirements of both of those traditions, the necessity of withstanding rough treatment at sea and, at the same time, the ability to carry substantial merchandise.

The solution decided upon was a balanced three-fold support scheme, with equal primary strength coming from the mast step and stays. The lesser support coming from the mast partner would be slight prevention of side-to-side leaning of the mast (and this would be precisely what the stays could least effectively counteract).

Ironically, the deck-level (or, more accurately, raised) partner may now be the most understood aspect of the mast assembly despite the dozen or so mast steps excavated. The Kyrenia ship and its close analogy to an

early Cypriote clay model (ill. 6, page 15) have proven invaluable in interpreting the previously mysterious parastatae and mesodme.

The Kyrenia discovery is of such importance that some detail needs to be recounted. Two smaller (52 cm in length) timbers lie to the sides of and slightly forward of the mast step. Each of these members shows a hole for the stanchion support of a transverse timber which extends inboard only as far as the side of the mast step. The resulting gap allows for removal of the mast by tilting it backwards over the fulcrum created by the aft mast partner beam. Stanchion holes on the mast step timber itself are tell-tale in this regard. Extrapolating from the Kyrenia evidence, in each case where such holes are found (e.g., at Cavalière and on the Madgrague de Giens, Île Plane à Marseille 1, Pointe de la Luque B and Anse Gerbal vessels) a complementary raised-level partner can be envisioned. The aft cross-beam on the Kyrenia ship runs across the entire breadth of the hull and is supported just off center on a stanchion fixed into the long, narrow mortise cut in the aft of the step.

What is particularly noteworthy as well is the relatively low situation of this array (only some one meter above the step) and, consequently, its weak structural character. This leads to the hypothesis that support

was not the primary role of the mast partners, but rather that these timbers constituted a ready mechanism for unstepping the mast.<sup>44</sup> Under such a theory, primary support for the mast would come from both the step and the stays (with some secondary effect of sideways bracing of the mast by carlings as hypothesized by Casson<sup>45</sup>). This hypothesis is strengthened by another at first mysterious situation. Interestingly, there are only three notches cut into the shelf clamp of the Kyrenia ship on either side-- one to accommodate the aft cross-timber, one for the abridged forward transverse timber and one for an unrelated cross-beam farther to the stern. It should be remembered that the Kyrenia remains had a possible five different "settings" for the mast step (far too many to have been coincidental). Curiously, however, the lack of corresponding notches in the shelf clamp would seem to indicate that the mast partner bases were not equally mobile. And this would not be necessary if the partners served primarily in a fulcrum capacity for which it would be important only for the mast to be planted somewhere between the aft cross-timber and the forward abridged beams.

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<sup>44</sup>J.R. Steffy, personal communication.

<sup>45</sup>Casson (supra n. 42) 47.

Still, another explanation is possible. The hypothesized carlings running longitudinally between those timbers could have been replaceable, with the different sets constituting a series of notched girdles for the mast at different positions along the keel. Or, one oval hole could have been adjusted with various locking devices (cf., Gokstad, *infra*). Whatever the case may have been, the relatively feeble stanchion supports in the mast partner would not have provided real structural support.

An understanding of the mast partner serves to clarify somewhat the need for the complicated mast step arrangement. Because the fore and aft movement of the mast was not restricted at all by the mast partner, the stays required a correspondingly greater assurance against such mobility at the keelson level. Clearly, a "locking in" of the mast foot was crucial. Consistent with the archaeological evidence available, this could have been achieved in a number of ways.<sup>46</sup>

The mast, by virtue of the "carving" of its base tenon, would, in effect, spill over and rest, around its

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<sup>46</sup>For example, D. Higuera, in "Hipótesis sobre el Asentamiento de los Mástiles Abatibles en Naves Mediteraneanas de Epoca Clásica" (unpublished paper presented at the VI Congreso Internacional de Arqueología Submarina, Cartagena, Spain 1982), has proposed a three-fold system of (1) support of the deck above, (2) reinforcement of the mast, and (3) creation of a "funnel" to guide the mast into its setting.

perimeter, on the superior surface of the step. This "spill over" would butt up against the surrounding mortises which in turn would constitute the "footings" for an enveloping box arrangement. The support weakness in the boxing scheme would be forward, due to the arc of the main cavity. To compensate against any tendency for the mast foot to pop out in that direction, supplementary footings would be necessary--and this is the case on the Bon Porte and Kyrenia ships with their two deeper square mortises forward.<sup>47</sup> The Cavalière remains do not show this additional feature, though this is perhaps due to the "simpler" construction of that ship already suggested. Also, the arc of the main cavity curves to a much steeper (almost right) angle at Cavalière which would tend to lock the mast in more firmly. By the time of the Chrétienne A ship the forward mortises have disappeared, replaced by a more effective mechanism, the inverse notching of the main cavity (of which an inkling was seen in the Kyrenia ship). It is doubtful that the mast tenon was curved to fit this inverse as well, for that would defeat the purpose of the

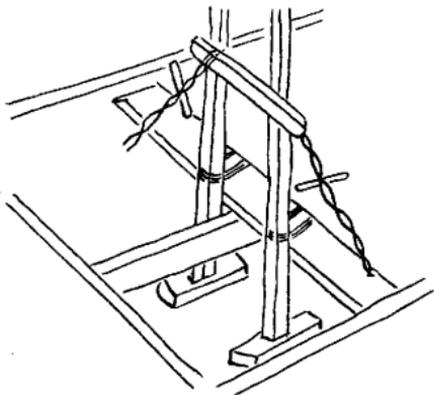
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<sup>47</sup>Higuera (supra n. 46) proposes that the fourth mortise forward served to house a retractable stanchion which prevented the mast from rotating. This also would accommodate the fastening atop the forward part of the step of an "open box" which guided the foot of the mast and avoided its "fishtailing" during dismount. While mechanically supportable, such an arrangement would seem to be an undocumented elaboration.

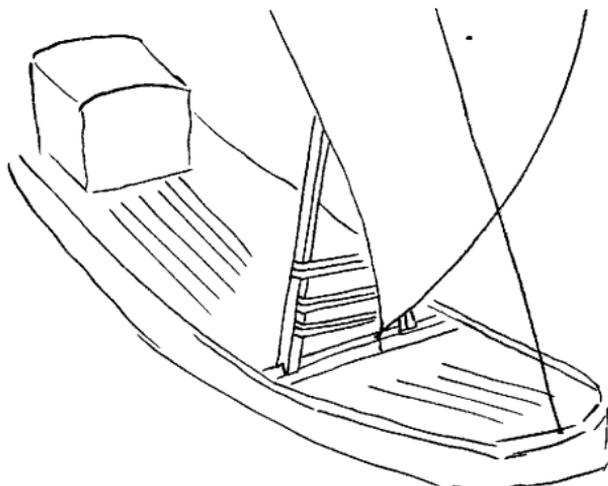
inclined cavity permitting an easy dismount. The "boxing" remained, therefore, as evidenced by the continued presence of the shallow lateral mortises and was most likely jointly footed in the inverse cavity. In the Chrétienne A and Madrague de Giens (with its two inverse notches) ships there clearly would have been room for such a set-up. In the Île Plane à Marseille 1 wreck it does not appear that there was.

It is possible that none of these features, or at least forerunners of them, is new, however. And here is perhaps the "solution" to the mast step mystery. As early as Old Kingdom Egypt, bipod masts appeared. It has been suggested that these masts were supported by "tabernacles" (ills. 35 and 36). Indeed, the very concept of the Latin tabernaculum ("tent") recalls the Greek τράπεζα ("table") description of the step mentioned previously. That such an additional shelf feature might have been found on the often extremely tall Nile River craft would not have been surprising. The bipod arrangement itself was partly an outgrowth of the need for further stabilization of these towering masts, and a deck-level tabernacle would have been a logical extension.

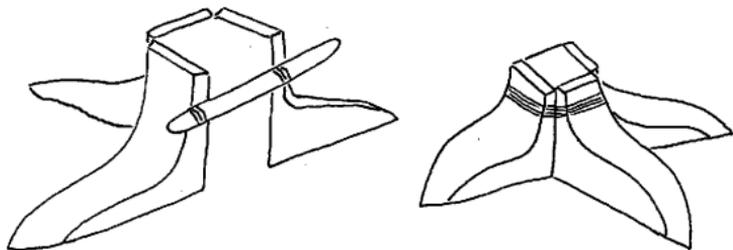
The "boxing" arrangement around the mast step also may find its roots in Egyptian technology. By the Middle Kingdom, primitive bracing appears about the step (ills. 37 and 38). These tripod and semicircular sleeves or



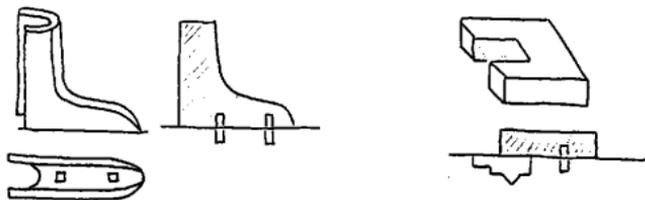
Ill. 35. Old Kingdom Egypt Mast Array. (Sketch based on B. Landstrom, Ships of the Pharaohs [London 1970] 47)



Ill. 36. Old Kingdom Egypt Ship. (Sketch based on B. Landstrom, Ships of the Pharaohs [London 1970] 4 8)



Ill. 37. Middle Kingdom Egypt Mast Support.  
 (Sketch modelled on H.E. Winlock,  
Models of Daily Life in Ancient Egypt  
 [Cambridge 1955] plate 85)



Ill. 38. Middle Kingdom Egypt Step Sections.  
 (Sketch modelled on W. Werner and  
 A. Göttlicher, Schiffsmodelle im  
 Alten Aegypten [Wiesbaden 1971]  
 plate XXXVII)

knees, represented in contemporary models, were dowelled into the mast step and simply lashed around the mast itself, if bound to the mast at all. Over the centuries, it is not difficult to envision an evolution of these simple dowel fastenings into the more sophisticated mortising arrays of the Greek and Roman periods.

A further significant change has obviously occurred by the fourth century A.D. as seen in the Pointe de la Luque B and Port Vendres A wrecks. First, the main mast cavity appears proportionately much more shallow. This may have a simple technical explanation. The lateen rig, requiring a far shorter main mast, appears in representations by the fourth century A.D. at least, and perhaps as early as the second.<sup>48</sup> A shorter mast would substantially decrease the support requirement at the keelson level. The very small supplementary notches on the Pointe de la Luque B ship are aft and of a depth (1.5 cm) that would provide very little foundation. The Port Vendres A remains are even more puzzling. The fact that the inverse notch, itself in the profile of a small main cavity, and two of the four square mortises have been filled in leads one to agree that this might have been a refashioned mast step.

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<sup>48</sup>Casson (supra n. 42) 47.

In any event, the mutual exclusiveness of the earlier lateral shallow mortises and the small square mortises that replaced them by this period must be indicative of a clear technological advance.

The shift somewhere between the mid-first century B.C. (Île Plane à Marseille 1 wreck) and the late Empire (Pointe de la Luque B and Port Vendres A ships) from a step supported on transverse frames to one resting on longitudinal stringers is a highly significant evolution. The new system could conceivably allow greater flexibility in moving the mast step forward and aft as the sailing situation might require. It was seen that this maneuverability was a concern as early as the fourth century B.C. (Kyrenia ship). Now the precise, and possibly numerous, notchings necessary for a frame-supported mast step would no longer be required. On the other hand, the insert of structurally weak stringers would indicate that the step was not envisioned as a keelson (see Chapter IV).

Only a few miscellaneous points remain to be treated. A final vestige of the Egyptian tradition is the mast crutch (ἱστοδόκη: histodoke). Casson observantly comments that the crutch normally would have been aft since,

at least in the Iliad (I. 434), the mast is described as being lowered by the forestays.<sup>49</sup> Such a conclusion is consistent with the arc of the main mast step cavities which have been surveyed. The mast could only have been lowered to the stern with the vertical face of the cavity to the rear. It would not have been surprising, therefore, to have found a crutch on early, small undecked merchantmen (perhaps, for example on the Kyrenia or Bon Porté vessel). On later decked ships of deeper draft such a procedure would have been logistically unfeasible.

Lastly, the rake of the mast is little understood. It will be remembered that excavators at Bon Porte hypothesized an angle of 1° while the reconstructors of the Kyrenia ship claimed a 3° tilt. Conceivably the angle of the rake of the mast is tied to the position of the mast along the keel. In the case of the Kyrenia vessel the varying mast step positions may or may not have been accompanied by different angle settings. The mechanism for this, of course, would interject a further complication into the mast step arrangement.

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<sup>49</sup>Casson (supra n. 42) 47, n. 30: οἱ δ' ὅτε δὴ λιμένος πολυβενθίος ἐντὸς ἴκοντο, ἱστία μὲν στείλαντο, θέσαν δ' ἐν νηϊ μελαίνῃ, ἱστὸν δ' ἱστοδόκη πέλασαν προτόνοισιν ὕφεντες, κορπαλίμως "When they were now within the deep harbor, they furled the sail and stowed it in the black ship, and the mast they lowered by the forestays and quickly brought it into the crutch"; see, also, Odyssey II. 425.

## CHAPTER IV

## DIMENSIONS AND FASTENINGS:

## MAST STEP OR KEELSON?

The mast step is, quite simply, the footing into which the mast is set. By Mediterranean tradition that footing has been placed in a centered, longitudinal timber of varying lengths.<sup>50</sup> A keelson is likewise an internal longitudinal member which sits above the keel, but in this case one whose primary function is to provide additional structural support. By the very identity of location of these two structures it might be expected that they would:

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<sup>50</sup> The wood of ancient ships has never been systematically studied. It is not unexpected, therefore, that the wood types of mast steps are given brief treatment when discussed at all. The wood is described as "soft, white, resinous wood" for the Bon Porté ship by Joncheray (supra n. 1) 32; as pine for the Kyrenia vessel by Steffy (supra n. 8); Pinus leucodermis or Bosnian pine for the ship at Cavalière by Charlin, Gassend and Lequément (supra n. 11) 77; Pinus abies for the Cap del Volt find by Foerster 1982 (supra n. 15) 56; "softwood, very probably pine (Pinus) species" for the Serçe Liman keelson by Steffy (supra n. 38) 26. The step of the Madrague de Giens ship was of oak according to Tchernia and Pomey (supra n. 3) 110, and the artemon step of the Torre Sgaratta remains of elm as noted in Throckmorton 1969 (supra n. 25) 288.

Similarly, the workmanship evident in isolated ship components is not given appropriate attention. It is rare that a comment, even as brief as that for the craftsmanship at Cavalière indicating traces of an adze, reported in Charlin, Gassend and Lequément (supra n. 11) 77, will appear concerning tool marks.

one day become an integrated unit. Such an assumption is not necessarily inevitable, however (cf., the much later first Contarina ship<sup>51</sup>). The question arises, then, whether the keelson was an outgrowth of the mast step or whether it evolved as an independent concept in the mind of the ancient shipwright as part of the trend toward greater reliance on skeletal support. It is submitted that the latter explanation is the correct one.

For five hundred years there occurred little more than cosmetic changes in the manner of securing the mast step in the ship's hold. The system of notches across the under surface of the step designed to fit over the frames and maintain the step in place by the weight of the mast alone proved quite satisfactory. An expected increase in the number of notches seen in early small craft from the two at Bon Porté and four in the Kyrenia vessel to ships of the first century B.C. (the Chrétienne A and Dramont A wrecks) represents less a recognition of the need for more notching than the practical accomodation to the increasing number of frames made necessary by ships of greater and greater capacity. Even then, the large Chrétienne A (at an

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<sup>51</sup>See M. Bonino, "Lateen-rigged Medieval Ships," International Journal of Nautical Archaeology 7 (1978) 9-28, and M. Bonino, personal communication, indicating forward and midship steps built upon a full length keelson.

estimated 24 to 32 meters and 200 plus tons) and Madrague de Giens (43 meters and 400 tons) ships had steps notched to accommodate only ten and eight frames, respectively.

In fact, it is clear that it is actually unnecessary to have the step closely fitted to all the frames upon which it sits. The normal framing pattern in Greco-Roman hull construction consisted of a regular alternation between frames with floors and half-frames. The mast steps on the *Cavalière* and *Chrétienne A* ships are maintained in place by notchings designed to receive only the floors and not the half frames. By the time of the *Dramont A* ship there is a slight bevelling to allow for the fit of the half frames, but those notches are too shallow to play a support role. The *Madrague de Giens* ship also displays this angled bevelling to accommodate the half frames.

Dimensions, and in particular length, of these early mast steps do not indicate a conscious movement toward their implementation as longitudinal supports at least for the larger ships where such support would most logically be expected. In fact, only the *Cavalière* (with an estimated length of 13 meters and a step reconstructed to 7.5 meters) and the *Cap del Volt* (with an estimated length of 13 to 14 meters and a step of 9.5 meters) remains give evidence of a mast step spanning a significant proportion of

the ship's overall length. The Cavalière ship is further suspect by the fact that the actual step remains are only one-half meter and the extrapolation is an unclear reconstruction.

Cap del Volt's wreck may legitimately have been the first example of a ship designed to employ the longitudinal member in the role of a structural support. However, it might not yet be accurate to describe the timber as a "keelson." Foerster and Pascual characterize the mast step portion of this timber as a "stringer incorporated into the keelson"<sup>52</sup>--and, in reverse, this is what a keelson will actually become, a member of hybrid purpose, meant both to support and to distribute the force of the mast as well as to provide longitudinal strength to the hull. It is of this latter aspect that the Cap del Volt wreck gives the first glimpse. And the reason that this wreck is centuries ahead of its time (not until the fourth century A.D. example of the Anse Gerbal from Port Vendres will a mast step/keelson even approach these lengths) may be readily explained, for the Cap del Volt ship had a flat bottom, almost without a keel, adapted for plying the shallow estuaries, tidal areas and deltas of northeastern Spain. The

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<sup>52</sup>Foerster and Pascual (supra n. 15) 55.

keel was essentially no more than a center plank with a width of 12 cm and a thickness of 6 cm, only slightly thicker than the planking (4 cm). It was protected by a shoe 2.5 cm thick. From within, the keel was indistinguishable from the planks. This is the very type of craft which would require some additional longitudinal support and the elongation of the mast step would have accomplished that purpose. Further, if this was intended as a keelson, it is curious that no supplemental fastening (e.g., mortise and tenon or bolt) fixed it to the keel and frames.

It is commencing with the fourth century A.D. ships that two features are consistently present--bolts and, through implication, a full keelson. The two are not unrelated. Evidence of bolting of the longitudinal member to the keel is a watershed, for at this point it is transformed from strictly a mast step to a legitimate "keelson." There is no design reason why ships of virtually the same size as those dated five hundred years earlier would now require bolt fastenings of the step to more stably secure the mast. The same primitive principles of notching and mast weight would continue to assure satisfactory stability for the mast. Conversely, the unbolted, usually short, mast steps of prior centuries would provide little fore and aft skeletal support. The bolts, then, must be related to the role of this longitudinal member as skeletal

support. In the case of the Port Vendres vessel, that keelson was over 7 meters in length with evidence at one end, if not both, that the keelson was scarfed into a continuing timber.

This development of a full length internal support is certainly borne out by the time of the eleventh century A.D. Serçe Liman ship with its "discoloration and pressure marks on frame tops and keelson bolts running through the keel from bow to stern."<sup>53</sup>

The reconstruction of the Serçe Liman vessel would point to a mast stepped slightly forward of midships between frames B and C. Not coincidentally, it is at this section that the exceptionally narrow keelson bolt spacing occurs (1.08 meters). It is not illogical to presume, therefore, that the reason for the closer spacing was to provide greater support at a point of stress--the main cavity of the mast step.

The lengths of the forelock bolts barely accommodate the moulded dimensions of the keel, frame and keelson. Since by this late stage in the development of ship construction the mast step would no doubt have been secured to the keel by bolts (it had been on the Pointe de la Luque B ship seven centuries earlier), it can be presumed that the

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<sup>53</sup>Steffy (supra n. 38) 20.

step was cut directly into the keelson and was not an independent member. The moulded and sided dimensions of the keelson would, of course, be sufficient for this (cf., the comparably sized Kyrenia and Cavalière ships).

By this time the keelson had assumed a role of primary structural importance. This was paralleled by a concomitant diminution in the size of the keel.

When one examines the evidence from intervening shipwrecks to determine whether there are any inconsistencies in the theory of development, the answer appears to be in the negative.

Working in inverse chronological order, iron bolts, possibly as long as 72 cm were found driven through the keel remnant at five frames (11, 14, 19, 25 and 27) on the Yassi Ada seventh century A.D. ship. The frames encompassed span approximately one-third of the keel's original full length and, thus, a full length keelson would not be hard to hypothesize. An interesting parallel to the bolt spacing at Serçe Liman also appears. The distance between frames 14 and 19 is about 1.6 meters and that between 19 and 25 is 1.45 meters. The substantially shorter spacing between 11 and 14 can be explained by the need for reinforcement of the keel-stern-post scarp. That between 25 and 27 may have been due to the fact that the mast would have been stepped in close proximity to midships (frame 28 or 29), additional fastening thereby being desirable.

Similarly, iron bolts were used in binding every second or third frame floor to keel and keelson in the fourth century A.D. Yassi Ada wreck.

The wreck found off Cape Taormina in Sicily,<sup>54</sup> possibly dated to the time of Hadrian,<sup>55</sup> yielded a copper bolt 71 cm long which can be presumed, with such a length, to have bonded keel, frame and keelson.

The Port Vendres A ship has been discussed previously. Its yield of an early version of a keelson is convincing due to the length of the longitudinal member and its bolted fastening. There is a weakness in its skeletal support in that it sits upon longitudinal stringers; however, this is a feature which will probably soon disappear.

The Pointe de la Luque B remains present an example of how this elongation of the central skeletal support was accomplished one stage earlier. Here, there were separate elements, a "carlingue" situated over the keel-stempost scarp, a central mast step/keelson and, by extrapolation, perhaps a similar reinforcing member at the keel-sternpost joiner. The excavators have suggested that the mast step complex is so far forward as to be possibly the step for an

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<sup>54</sup>Tchernia and Pomey (supra n. 3) 81, n. 19, citing G. Kapitän, "Schiffsfrachten antiker Bausteine und Architekturteile vor den Küsten Ostsiziliens," Klio 39 (1961) 304-309.

<sup>55</sup>van Doorninck (supra n. 34) 138.

artemon ("Les dimensions relativement faibles des encoches comparées à celles de l'épave de la Chrétienne A, par exemple, indiquent peut-être que l'on n'a pas affaire au mât principal mais au mât d'artémon"<sup>56</sup>). This does not seem to be borne out by analysis. First, the projection of frame 8 (ill. 27) resembles far more closely a midship section than a stem section. A midship frame projection of about 5 meters would correspond to a ship's length of perhaps 15 meters. Continuing the forward curvature of the stem to a depth in hold of 2.5 meters, one arrives at a distance of some 6.5 meters from the forward end of the ship to the main mast cavity, or a total overall length of approximately 14 meters. To assume Negrel's hypothesis, one would be suggesting a vessel of more than twice that size, a hypothesis inconsistent with the proportions and measurements of frame 8. Two other points also argue against such a conclusion. First, there is no indication that the mast cavity has any peculiar accommodation for the distinct rake of an artemon. Secondly, that very rake would seem to require a deeper, not a more shallow, cavity, capable of supporting the added stress of an angled mast (for the mast would now be lacking its prime means of support, its own perpendicular weight).

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<sup>56</sup>Clerc and Negrel (supra n. 30) 65.

The Roman wreck from Monaco presents evidence which, while inconclusive on its face, is consistent with its temporal context. Its date, third or fourth century A.D., would place it within the transitional mast step-to-keelson era. The bolt which was found joined only the keel and frame, ending in a square rivet which was only slightly recessed into the upper face of the floor. The "keelson" appears to sit atop this, actually resting on recesses in the internal planking. Such an arrangement is more akin to the keelson-stringer relationship of the Port Vendres and Pointe de la Luque B ships. As such, and with the inherent weakness created by affixing it to the stringers, the timber would arguably represent an early stage of keelson development. At the same time, the member appears too small at this point (9 cm sided and 15 cm moulded) to house the step complex. Several explanations come to mind, weighing in favor of either a mast step or keelson characterization, respectively. The salvaged remnant could simply be the narrow end of a flaring mast step such as is seen particularly in the Bon Porté and Chrétienne A instances. Or, the timber could indeed be a keelson, affixed by bolts which were not recovered. The mast step complex could then either be housed in an expanded section or could, conceivably, rest atop the keelson (as in the first Contarina ship, although there is no

evidence that such an arrangement existed at these early dates). In sum, it is not unexpected that in analyzing evidence from this transitional period, later excavators have been unable to categorize this timber absolutely as either mast step or keelson.

There are indications that bolted fastening may have occurred prior to this. A first century A.D. Roman ship found at Terrasini yielded a bolt.<sup>57</sup> And bolts were retrieved from the possibly first century B.C. wreck at Porto Badisco.<sup>58</sup>

Although ship timber remains often survive almost arbitrarily, wood adjacent to iron objects may be better preserved due to the infusion of the metal (e.g., the remnant at the tip of the bolt through frame 8 on the Pointe de la Luque B vessel). Therefore, it is significant that in not one pre-first century A.D. wreck is there an example of a longitudinal timber pierced by a metal fastening which would suggest more of a "keelson" support role. The observations of the late Professor Fernand Benoît need to be reassessed accordingly. He "distinguished two construction types of tenoned ships during the Roman period: 'single'- and 'double-keeled' ships. The 'double-keeled'

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<sup>57</sup> Tchernia and Pomey (supra n. 3) 83, n. 19, citing V. Giustolisi, Le navi romane di Terrasini (Palermo 1975) 31.

<sup>58</sup> Tchernia and Pomey (supra n. 3) 83, n. 19.

ships all had keelsons, were flat-bottomed like the Titan and Dramont ships, were all of under 150 tons, and were not lead-sheathed. By 'double-keeled' Benoît meant ships with very heavy multiple keelsons."<sup>59</sup>

Benoît admittedly was working from the far smaller sample of ancient shipwrecks reported twenty years ago. The data reviewed in this chapter indicate that there did, indeed, come a point at which "double-keeled" vessels with substantial keelsons were constructed. The evidence would seem to point, however, to the fact that ships with keelsons were an evolution from ships without, not a contemporaneous variety of craft. Table 1 compares keel and keelson cross-sectional areas for all of the ships described in this analysis. What should be immediately obvious from prior discussion and the comparative table are the facts that (1) the Titan and Dramont ships are by no means the only examples of the Roman era with internal longitudinal timbers (every vessel surveyed had such) and (2) the huge members found on the Titan and Dramont ships were more likely mast steps than keelsons. This latter observation is based upon (1) the absence of numerous, regular fastenings, indicative of a keelson role, prior to the Pointe de la Luque B wreck (fourth century A.D.) and

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<sup>59</sup>P. Throckmorton, "Romans on the Sea," in G.F. Bass ed., A History of Seafaring Based on Underwater Archaeology (New York 1972) 73.

(2) the very size of the timbers.

As can be seen from the table, the mast step was consistently more massive than the keel on ships prior to the first century A.D. This might at first seem the reverse of what is to be expected. Surely, a support timber in an age of increasing "sloppiness" of mortise and tenon joints should be sturdier than a non-support timber. And, do not the slimmer cross-sectional dimensions of the later A.D. mast steps show that a bulky timber is unnecessary to secure the mast? The answer lies, again, in the evolutionary balance between step and keelson. The step does not need to be inherently bulky, so long as it provides stability. By the time the step was incorporated into a keelson, that stability was provided by the joinder of the keelson to the keel and frames. In earlier days, when the mast step stood alone, shorter and unfastened, stability required that the step provide its own sturdiness; hence, there was a massive quality about it.

<u>(1)</u> <u>Wreck</u>	<u>(2)</u> <u>Tonnage</u>	<u>(3)</u> <u>Keelson Cross-</u> <u>Sectional Area</u>	<u>(4)</u> <u>Keel Cross-</u> <u>Sectional Area</u>	<u>(5)</u> <u>Ratio</u> <u>(3)/(4)</u>
Bon Porte	20	237.5	57.6	4.12
Kyrenia	30	240	260	.92 *
Cavaliere	27	546	200	2.73
Chretienne A	200	1,296	--	--
Madrague de Giens	400+	2,475	1,225	2.02
Cap del Volt	50	432	72	6.00
Dramont A	--	836	440	1.90
Titan	--	1,152	728	1.58
Ile Plane a Marseille	--	660	--	--
Torre Sgaratta	--	--	--	--

Table 1. Proportionality of Keelson to Keel.

<u>(1)</u> <u>Wreck</u>	<u>(2)</u> <u>Tonnage</u>	<u>(3)</u> <u>Keelson Cross-</u> <u>Sectional Area</u>	<u>(4)</u> <u>Keel Cross-</u> <u>Sectional Area</u>	<u>(5)</u> <u>Ratio</u> <u>(3)/(4)</u>
Pointe de la Luque B	--	475 (220) **	375	1.27 (0.93) **
Caesar's Galley	--	500	875	0.57
Monaco	--	135	242	0.56
Anse Gerbal a Port Vendres	--	655	928	0.70
Yassi Ada IV	--	--	268	--
Yassi Ada VII	60	***	781	***

\* Possible different eastern tradition(?)

\*\* If averaged with forward "carlingue"

\*\*\* Due to sheer size of keel, keelson must have been substantially smaller or it would have survived

Table 1 (Cont.'d).

## CHAPTER V

## THE GALLO-ROMAN SHIPS

No discussion of early European shipbuilding would be complete without some mention of the "local" tradition alternatively characterized as Celtic or Gallo-Roman. Found in Britain as well as in the central and northwest portions of the continent, plank-built ships typifying this style evidence a curious hybrid quality--"features which collectively do not occur in either the early Mediterranean or in Scandinavian ships" but "contain[ing] many similarities in construction technique which link them together into a general group."<sup>60</sup> Further bounding of this Celtic tradition is made difficult by the diversity of ship types found within it. The Blackfriars and Bruges ships are probably sea-going craft, while the great majority of remaining finds are river vessels or barges.

Analysis of the "mast steps" of these ships must take into account the very different purposes which many of them served, distinct both from the Mediterranean merchantmen and Scandinavian long-boats. The earliest example,

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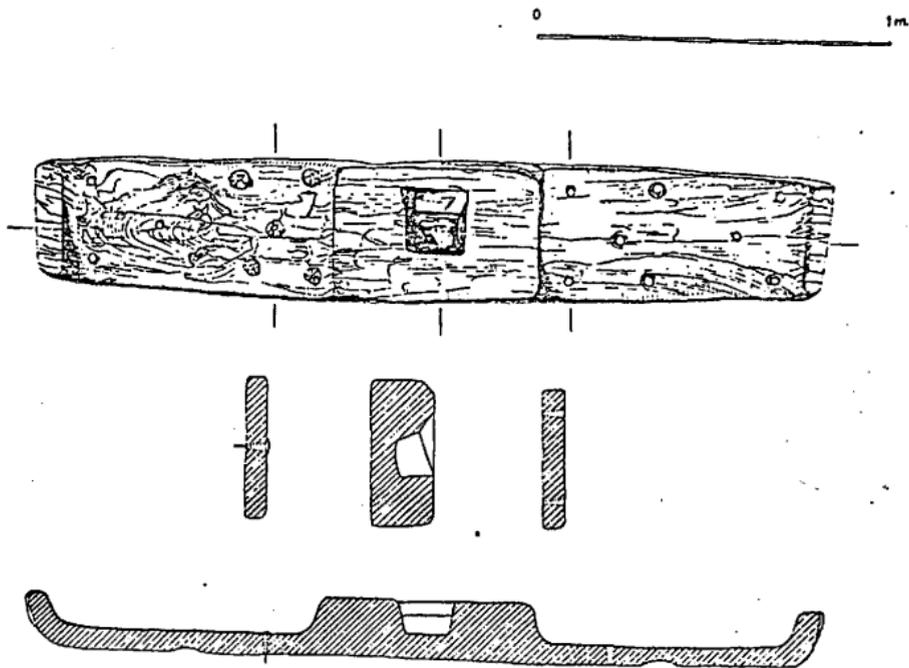
<sup>60</sup> Marsden (supra n. 3) 42, 51.

the Bevaix boat (ills. 39 and 40) from the turn of the first century A.D., exhibits a peculiar trait which is common to several later examples--namely, "the masts of four ...ships (Bruges, Blackfriars, Zwammerdam 4 and Bevaix) were surprisingly situated on ribs, the three published maststep ribs (Bruges, Blackfriars, Bevaix) having a somewhat similar unusual form, each with a central raised area, suggesting a common ancestry."<sup>61</sup> The apparent reduced strength from such an arrangement is perhaps explainable in two of the cases. The Bevaix boat was a lake vessel, destined to ply the relatively calm Lake Neuchatel of Switzerland and not the whimsical Mediterranean or stormy Baltic. The very dimensions of the boat, with its 1:6.7 breadth to length ratio and extremely shallow draft, attest to its intended use in a pacific environment. From the absence of archaeological evidence (e.g., stanchion or wedge support holes) any support in addition to the simple mast cavity would have to have been at deck level, though too close to the base of the mast to be overly effective. The sail quite likely constituted a complementary, not primary, means of propulsion.

The Zwammerdam craft mentioned by Marsden will be

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<sup>61</sup>Marsden (supra. n. 3) 53.



Ill. 39. Bay of Bevaix Step Schematic. (B. Arnold, "La barque gallo-romaine de la baie de Bevaix [lac de Neuchatel, Suisse]," Cahiers d'archéologie subaquatique 3 [1974] 142)



discussed later.

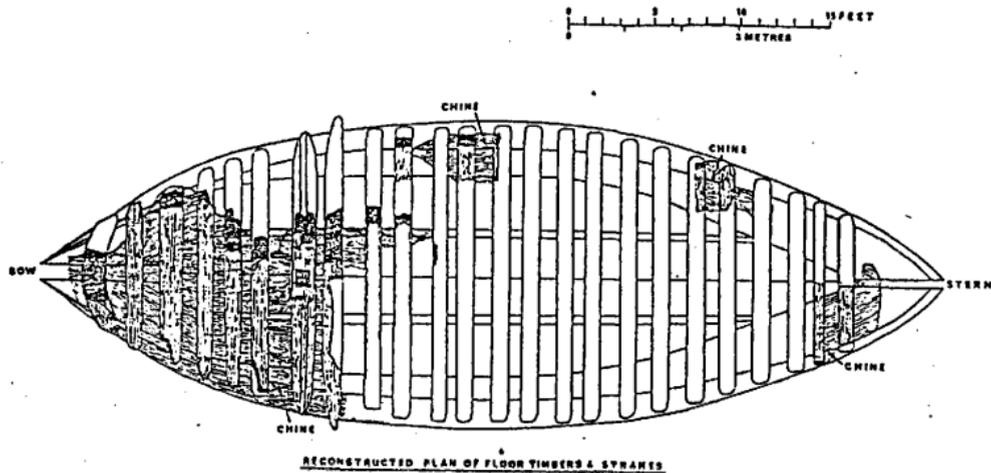
Stepping the mast on a frame is less understandable in the cases of the Blackfriars and Bruges ships. The Blackfriars ship (ill. 41), a building stone transporter almost certainly capable of minor ocean travel, more resembles the traditional merchant ship in dimensions (a beamy 1:2.5 breadth to length ratio and deep 2.5 meter height), shows a mast cavity (ill. 42) of substantial size (35 cm wide, 27 cm long, 15 cm deep) and was "probably propelled by a single square sail."<sup>62</sup> The internal depth of the ship would have necessitated a deck,<sup>63</sup> a fact that supports Marsden's hypothesis of lower and deck-level mast "partners":

"If [the timber identified as a mast step] contained a mast pillar, then the mast itself would have fitted into a tabernacle at the upper end of the pillar at deck level so that it could be lowered... Protruding horizontally from the forward face of the timber, and about 6 inches above its bottom, were two iron nails, one on each side of the step... Between the head of the nail and the face of the timber was a broken piece of wood about 2 inches thick. This seems originally to have continued across in front of the mast-step... The purpose of this board would have been to strengthen the forward side of the mast-

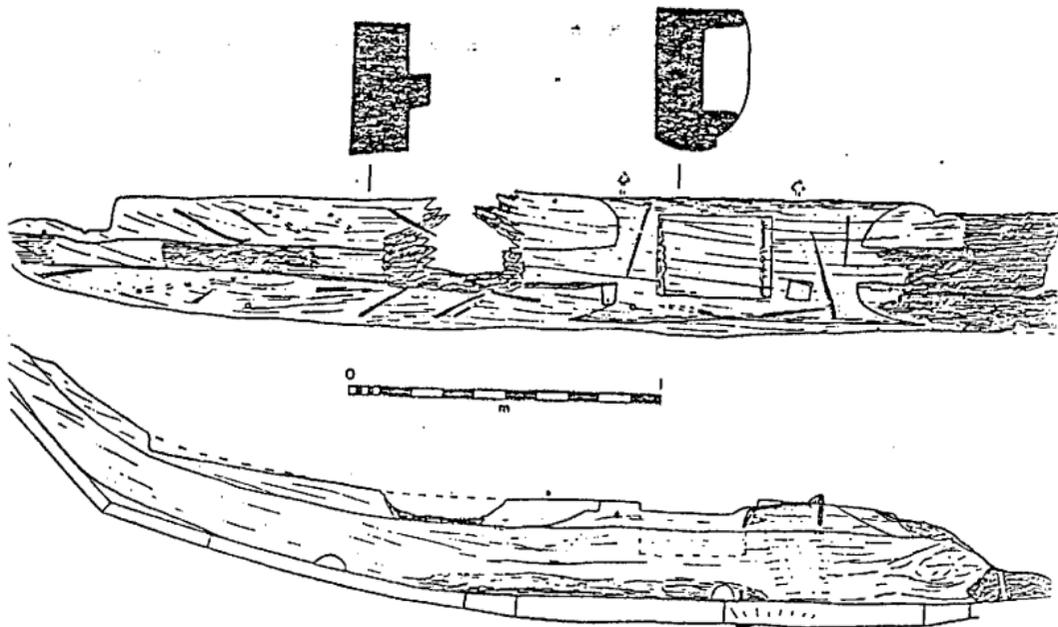
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<sup>62</sup>P. Marsden, "Ships of the Roman Period and After in Britain," in G.F. Bass ed., A History of Seafaring Based on Underwater Archaeology (New York 1972) 121.

<sup>63</sup>Marsden (supra n. 62) 121.



Ill. 41. Blackfriars Hull Schematic. (P. Marsden, A Roman Ship from Blackfriars, London [Guildhall 1965] 25)



111. 42. Blackfriars Step Schematic. (P. Marsden, "A Boat of the Roman Period Found at Bruges, Belgium, in 1899, and Related Types," International Journal of Nautical Archaeology 5 [1976] 45)

step which was otherwise only 2 inches thick... On either side of the mast-step, cut into the after side of the raised surround of the step, there was a small square hole about 1 inch deep. The purpose of these is not certain, but they may have been mortises into which were fitted upright stanchions. Presumably at deck level there was a special timber construction connected with the mast, and the stanchions would have helped to support it. Confirmation that this special construction at deck level did exist is given by an extra side frame... on the port side of the ship, level with the [mast step timber]."<sup>64</sup>

Two other features of the Blackfriars ship are worthy of comment. Interestingly, the mast step cavity lies some 5 inches off the center planking seam of the vessel. Although it has been suggested that this arrangement would reduce the effects of downward pressure by the mast on the hull joints, it is equally likely that precise central positioning of the socket was unnecessary and that the shipwright's ignorance of geometry indeed made such exactness unlikely.<sup>65</sup> Secondly, in an accommodation observed to an even greater extent in the Bruges ship,<sup>66</sup> the mast cavity is situated toward the forward side of the timber.

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<sup>64</sup>P. Marsden, A Roman Ship from Blackfriars, London (Guildhall 1965) 19.

<sup>65</sup>J.R. Steffy, personal communication.

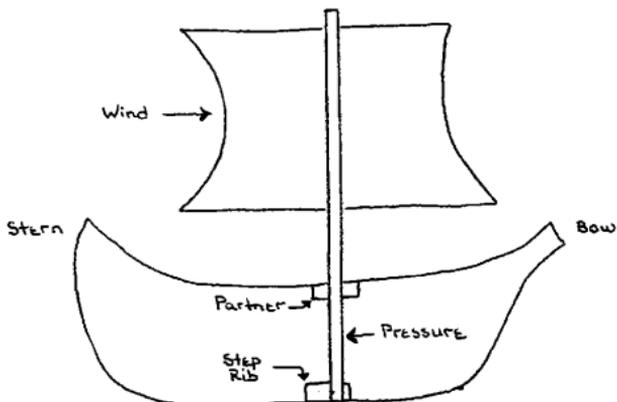
<sup>66</sup>Marsden (*supra* n. 3) 36.

The reason for this is perhaps to give strength to the afterside of the floor timber to counteract the pressure aft of the foot of the mast caused by the leverage forward of its upper part, the deck acting as a pivot (ill.43). This is a concept analagous to the common placing of the right angle surface of the Mediterranean mast cavity to the rear. Still, an exception to this thesis is evident in the Bevaix boat where the mast cavity lies toward the rear side of the timber (ill. 42, page 93). That may be only further indication of the limited role of the sail in that ship and the consequent lack of concern for maximum structural solidity.

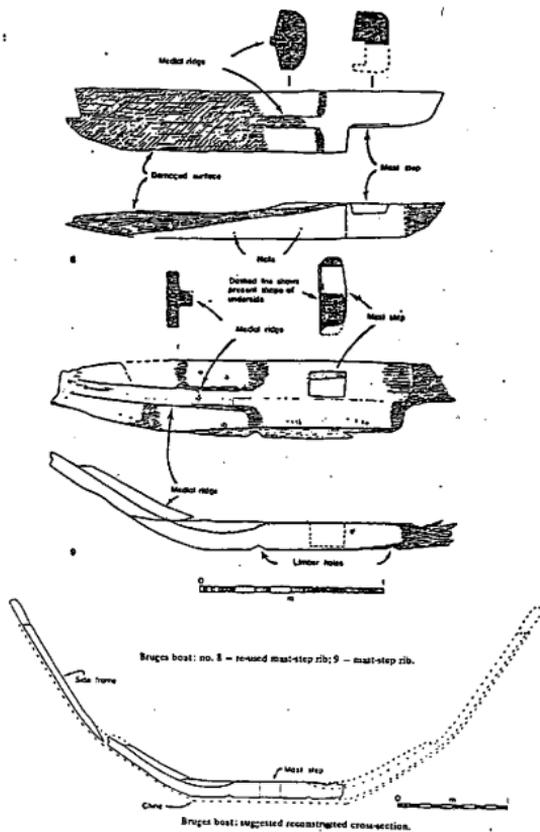
The Bruges (Belgium) boat (ill. 44) from the late second or early third century A.D. (though it has been dated as late as the fifth of sixth century<sup>67</sup>) is significant for its mast step parallels to the Blackfriars and Bevaix ships. Here, as on the Blackfriars ship, the mast step timber has a raised medial ridge extending out from the mast cavity. Importantly, a second timber also evidences mast step features: "This timber seems to have been originally carved as a floor-timber with a mast-step for a vessel of larger size than the Bruges boat, but it was

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<sup>67</sup> Marsden (supra n. 62) 123.



Ill. 43. Off-Center Mast Step Mechanics. (Sketch modelled after P. Marsden, "A Boat of the Roman Period Found at Bruges, Belgium, in 1899, and Related Types," International Journal of Nautical Archaeology 5 [1976] 37)



Ill. 44. Bruges Step Schematic. (P. Marsden, "A Boat of the Roman Period Found at Bruges, Belgium, in 1899, and Related Types," International Journal of Nautical Archaeology 5 [1976] 33, 39)

probably never completed and used as such and was modified perhaps to form a thwart to help support the mast in the Bruges boat."<sup>68</sup> That timber preserved the distinctive medial ridge on its upper surface and traces of the actual mast socket.

The Zwammerdam boats mentioned previously include both "dugouts" and barges. A number of remains were discovered near modern Rotterdam at the site of the first century A.D. Roman fort of Nigrum Pillum. Of the three more primitive dugout types found, one (Zwammerdam 3) showed evidence of a "small maststep."<sup>69</sup> The more significant finds were the "long, flat-bottomed river barges, with no keel, and which could be of very great size."<sup>70</sup> The distinctive L-shaped plank, cut from a single timber, forming the right angle junction of the side and the bottom of such boats suggests that these barges "belonged to a very primitive group of vessels which had developed from dugout craft of the 'Utrecht type,' the dugout having been split

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<sup>68</sup>Marsden (supra n. 3) 31-32.

<sup>69</sup>M.D. de Weerd, "Ships of the Roman Period at Zwammerdam/Nigrum Pillum, Germania Inferior," Research Report No. 24, Council for British Archaeology (London 1978) 16.

<sup>70</sup>Marsden (supra n. 3) 44.

longitudinally"<sup>71</sup> with additional planks then inserted to increase the bottom width. In each of the three barges found to date there was observed

"a small, rectangular socket, its small size being out of all proportion to the size of the vessel. This socket was cut either into a keelson or into a rib and it is presumed that this once contained a small mast or towing post. The socket cut into the floor-timber...is somewhat similar to the mast-step timbers in the Bruges and Blackfriars ships in that it usually lies in a raised central part of a rib."<sup>72</sup>

The similarity of Zwammerdam 4 to the Bruges and Blackfriars ships is not as understandable as its analogy to the Bevaix boat. In the latter case, the dimensions (again a sleek 1:7.7 breadth to length ratio and shallow 1.2 meter height as compared to the 1:6.7 ratio of the Bevaix boat) and the intended use (non-ocean transport) justify a slightly less sturdy mast assembly. Nevertheless, the vessel was described as having "a large maststep for sailing, with additional constructional features, at one-quarter distance from the stern."<sup>73</sup> Unfortunately, the mast step has not been published, but the weakness

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<sup>71</sup>Marsden (supra n. 3) 46.

<sup>72</sup>Marsden (supra n. 3) 46.

<sup>73</sup>de Weerd (supra n. 69) 17.

inherent in a lateral step may have been partially compensated for by the "additional constructional features" (presumably mortises or the like for supporting members). Still, it must be realized that, even if the sail were a primary source of propulsion in this instance, the barge was destined for a river milieu.

The smaller Zwammerdam 2 had set in its keelson a "maststep, too small for sailing, at one-quarter distance from the stern...possibly for a towing post," while for the similarly sized Zwammerdam 6, there is reported only a "maststep at one-quarter distance from the stem," again presumably set in a keelson.<sup>74</sup>

The post-Roman Utrecht boat, found in the Netherlands and dated to the eighth or ninth century A.D., is an anachronistic vestige of the Zwammerdam 3 dugout type. The siting of the mast well forward is by now typical of vessels of the Celtic, as opposed to the Scandinavian Viking, tradition--a characteristic whose explanation is consistent with what has been noted previously about the role of many such watercraft.

"The advanced position of the mast has a natural explanation, provided by representations of, for example, Roman river ships.

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<sup>74</sup>de Weerd (supra n. 69) 17.

These show tow ropes leading from a short mast forward to bargemen on land. This suggests that the Utrecht ship is a river vessel. That is not to say that this type of hull could not be fitted out as a sea-going ship with a centrally placed sail-bearing mast."<sup>75</sup>

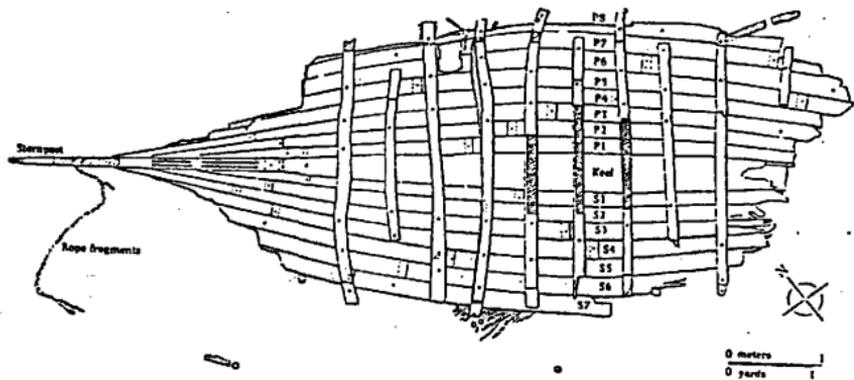
Finally, the Graveney boat (ill. 45), excavated in Kent, England, and dated between 900 and 1000 A.D., represents a bit of an enigma due to the desecrated state of her remains. Though hypothesized as a cross-channel trader due to the remnants of diverse cargoes of hops, Roman tile, Kent ragstone and unfinished querns of Rhine basalt found with the hull, it is impossible to guess at the number of oars which propelled the ship or the method for steering. There is a distinct possibility that a sail provided some propulsion: "She may once have had a sail: three of the central frames have shallow rebates that could have taken a mast step, but for some reason, these rebates had been filled in making it impossible even to mount a mast and sail."<sup>76</sup>

The clearest observations that can be deduced from the

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<sup>75</sup>O. Crumlin-Pedersen, "The Vikings and the Hanseatic Merchants: 900-1450," in G.F. Bass ed., A History of Seafaring Based on Underwater Archaeology (New York 1972) 186.

<sup>76</sup>Muckelroy (supra n. 9) 76.



Ill. 45. Graveney Boat Hull Schematic. (K. Muckelroy, Archaeology Under Water [New York 1980] 76)

Gallo-Roman or Celtic mast step tradition are ones directly related to the intended functions of these boats. The "masts" which these exhibit serve either in a towing capacity (in most instances) or are adequate to propel only ploddingly bulky Channel or coastal merchants (Blackfriars and Bruges boats). The stepping of a mast in a transverse frame rather than in a "keelson" type timber (however, cf. Zwammerdam 2 and 6) is a major structural inadequacy. On no occasion does that mast step timber indicate provision for additional supporting structures (i.e., mortises). Rather, that additional support must have come from a deck-level mast partner analagous to that of Scandinavian vessels (and as hypothesized by Marsden of the Blackfriars boat).

All of the evidence points to a mast step technology which was little influenced by its Mediterranean counterpart. The developing craft of the Greco-Roman shipwright was reflected in large degree in the evolving sophistication of the mast step assembly. The concern for efficient sea-going merchant carriers which necessitated that sophistication was unimportant to his Celtic brethren.

## CHAPTER VI

## THE SCANDINAVIAN TRADITION

The tradition of hull construction in Scandinavia, entirely distinct from those of central Europe and the Mediterranean, demonstrates an evolution in the mast step even more readily charted due to finds enjoying exceptional preservation. In Norway, the practice of burying nobles in ships fashioned with the finest technology of the age was enhanced by ideal soil conditions to produce largely-intact specimens for reconstruction. The Danish ships of Roskilde suffered a less dignified fate--scuttling to provide a channel blockade against raiders--but have yielded an equally enlightening record of construction.

In a truer sense, the trials and errors of the Norse peoples in struggling with this new-found concept of sailing find their analogy more properly in that primitive era when men of the Near East, and later the Aegean, first adapted their papyrus craft or Cycladic long-ships to take advantage of the winds. The very design of Viking ships never really progressed beyond that "long-ship" stage. It was more suited to rowing, and the inherent incompatibility resulting from the tenacious reluctance of the Vikings to alter that design led to its eventual demise.

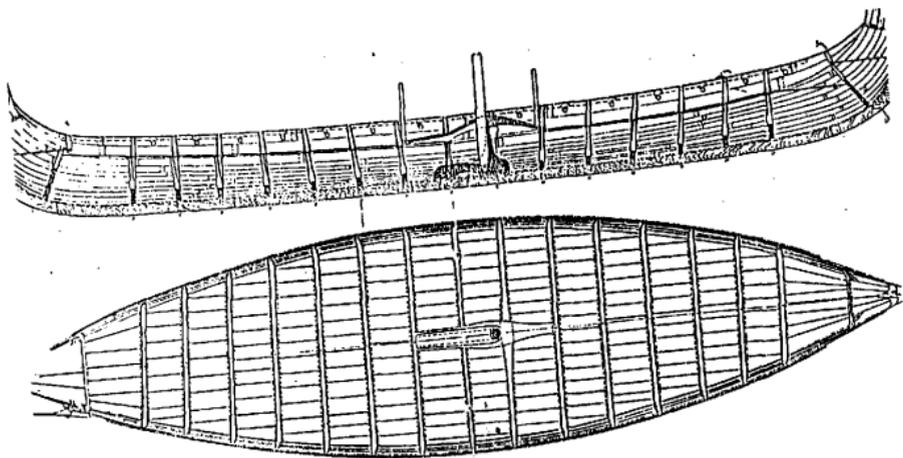
It is not until the seventh century A.D. that sailing vessels were first used in Scandinavia.<sup>77</sup> Moreover, the ninth century Oseberg ship (ill. 46) from Norway provides the earliest direct evidence for mast and sail.<sup>78</sup> This ship was over 20 meters in length and, with its 1:4.2 breadth to length ratio, was designed to be sailed or rowed by 30 oars. Richly carved for the burial of a noblewoman, the ship had nevertheless once served more than a ceremonial role. It is here that one first sees the bi-level method of mast support which forms the backbone of the Viking sailing scheme. Rabbetted over the keel, but spanning only two frames (a distance of some 1.8 meters), is the large oak "crone" which contains a hole cut to receive the mast.<sup>79</sup> Only two rather scanty cleats provide stability against sideways displacement. Not a true keelson in the sense that it is not intended to provide longitudinal support to the hull, it was cleverly hewn from a timber having a branch still extending vertically just ahead of the mast, providing support while also steadying the mast

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<sup>77</sup>A.E. Christensen, "Scandinavian Ships from Earliest Times to the Vikings," in G.F. Bass ed., A History of Seafaring Based on Underwater Archaeology (New York 1972) 165.

<sup>78</sup>Christensen (supra n. 77) 166.

<sup>79</sup>A.E. Christensen, Guide to the Viking Ship Museum (Oslo 1980); A.E. Christensen, Boats of the North (Oslo 1968).



Ill. 46. Oseberg Ship Hull Schematic. (T. Sjøvold, The Viking Ships  
in Oslo [Oslo 1979] 16-17)

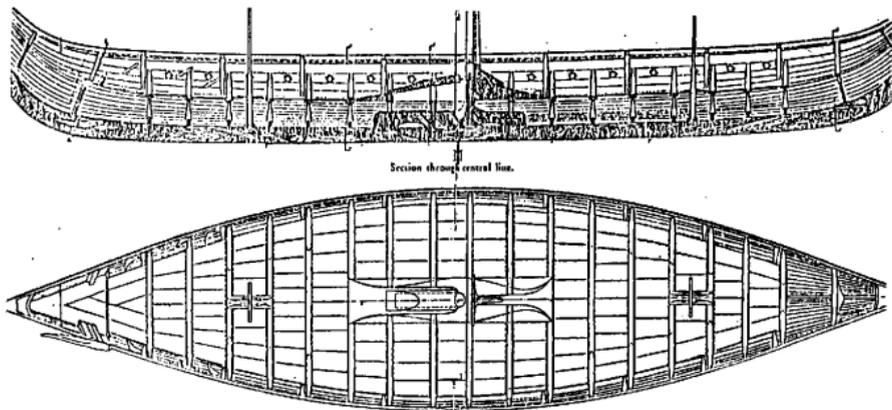
partner (or "fish") which is partly set into it.<sup>80</sup> The fish (appropriately named from its aerial piscine profile) serves in much the same upper girdling capacity as the tabernacle on early Egyptian ships and the hypothesized deck support on Celtic ships. Its humped shape adds further strength. Simply resting on the cross-beams, "plugged down fore and aft,"<sup>81</sup> and extending over four frames (a distance of some 3.2 meters), the mast partner shows a massive solid forward section balanced by a long oblong central slot aft, within which the mast slides when raised and lowered. With the mast in the raised position, the slot was sealed with a snug-fitting oak "mast-lock."

Still, the frailty of the embryonic mast assembly found on the Oseberg ship is apparent from cracks in the mast partner repaired by two iron bands nailed on. Any deficiencies were already corrected by the time of the construction of the Gokstad (ill. 47, 48 and 49) and Tune (ill. 50 and 51) ships of the late ninth century. With "only one single example of decoration..., [o]therwise... devoid of decoration..., in stability, serviceable construction and building [the Gokstad ship] is, in fact,

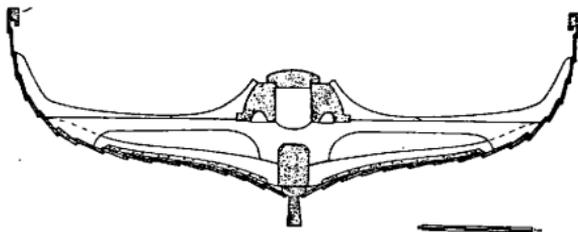
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<sup>80</sup>Christensen (supra n. 77) 166.

<sup>81</sup>Christensen 1968 (supra n. 79) 36.



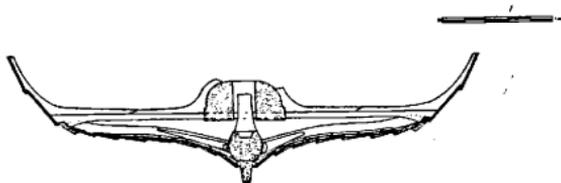
Ill. 47. The Gokstad Ship. (T. Sjøvold, The Viking Ships in Oslo  
[Oslo 1979] 64-65)



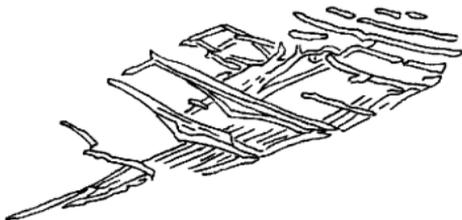
Ill. 48. Gokstad Hull Section. (A.E. Christensen, "Scandinavian Ships from Earliest Times to the Vikings," in G.F. Bass, ed., A History of Seafaring Based on Underwater Archaeology [New York 1972] 167)



Ill. 49. Gokstad Step. (A.E. Christensen, "Scandinavian Ships from Earliest Times to the Vikings," in G.F. Bass, ed., A History of Seafaring Based on Underwater Archaeology [New York 1972] 178)



- Ill. 50. Tune Ship Hull Section. (A.E. Christensen, "Scandinavian Ships from Earliest Times to the Vikings," in G.F. Bass, A History of Seafaring Based on Underwater Archaeology [New York 1972] 55)



- Ill. 51. Tune Ship Remains. (Sketch based on A.E. Christensen, Guide to the Viking Ship Museum [Copenhagen 1980] 27)

superior. Perhaps this is a result of the progress which must have been made during the [half century] interval between the building of [the Oseberg ship and it]."<sup>82</sup>

In particular, the "crone" and mast partner are of much sounder construction. The mast step of the 23.5 meter long Gokstad ship spans four ribs (3.75 meters) and "knees nailed to the ribs provide additional support."<sup>83</sup> Indeed, the mast partner has become so solid that two deep grooves were cut longitudinally to reduce its weight. The mast partner is notched and rests across beams over a span of six frames (5 meters) and is also supported by knees. The slightly smaller (19 to 20 meter long) Tune ship, which belongs to the same period as the Gokstad vessel, similarly exhibits a mast step sitting astride four frames and is supported sideways by knees nailed to the frames. The notched, knee-supported mast partner spans a slightly reduced five frames. By now a true "fish tail" outline has been achieved.

Another mast partner, found amidst hull fragments at Rong near Bergen, Norway, resembles that of the Tune ship although it is smaller (ill. 52).

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<sup>82</sup>Christensen 1980 (supra n. 79) 60.

<sup>83</sup>Christensen 1968 (supra n. 79) 35.



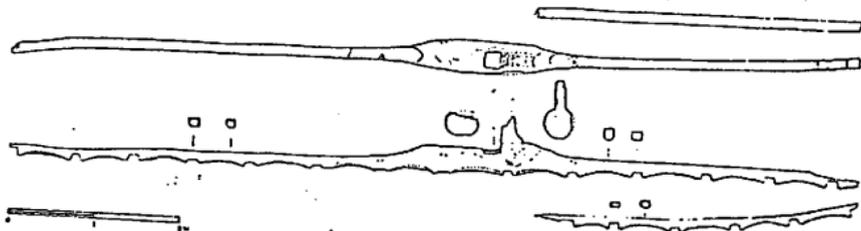
Ill. 52. Rong Mast Step Remains. (Sketch modelled after A.E. Christensen, "Scandinavian Ships from Earliest Times to the Vikings," in G.F. Bass, ed., A History of Seafaring Based on Underwater Archaeology [New York 1972] 178)

What diversity that did develop among Scandinavian ships was discovered through the excavation of the five late Viking (tenth to eleventh century) Skuldelev ships from the Roskilde Fjord in eastern Denmark. As Muckelroy has noted, "the Skuldelev find gave ship archaeologists a first opportunity in northern waters to examine ships built at the same time in the same tradition but for different purposes. Although the merchantmen and the warships were similar in form their proportions differed."<sup>84</sup>

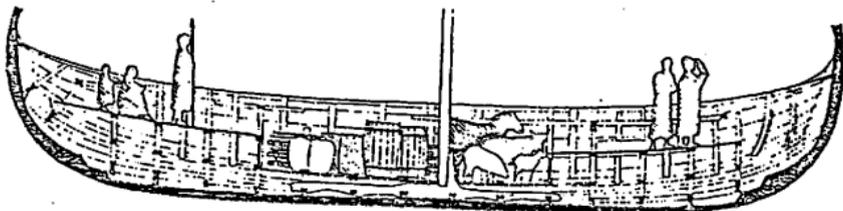
Indications of substantial mast-stepping systems were found on three of the ships. On the largest (which was at least 30 meters in length), a proposed drakker warship with provision for 52 oarsmen and 60 additional soldiers, the mast step had achieved a length of 10 meters, at least one-third the ship's overall length (ill. 53). Notched to fit over at least 14 frames, this oak timber was carved to its greatest moulded dimension over the 2 meter area immediately surrounding the mast cavity. Again, a natural branch offshoot extends vertically just ahead of the mast to provide added strength and possible support to a mast partner. The larger (16-meter long) merchant ship (ill. 54) is thought to be an example of

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<sup>84</sup>Muckelroy (supra n. 9) 74.



Ill. 53. Roskilde Wreck 2. Warship. (O. Olsen and O. Crumlin-Pedersen, Five Viking Ships from Roskilde Fjord [Copenhagen 1978] 132)



Ill. 54. Roskilde Wreck 1. Merchantman. (O. Olsen and O. Crumlin-Pedersen, Five Viking Ships from Roskilde Fjord [Copenhagen 1978] 121)

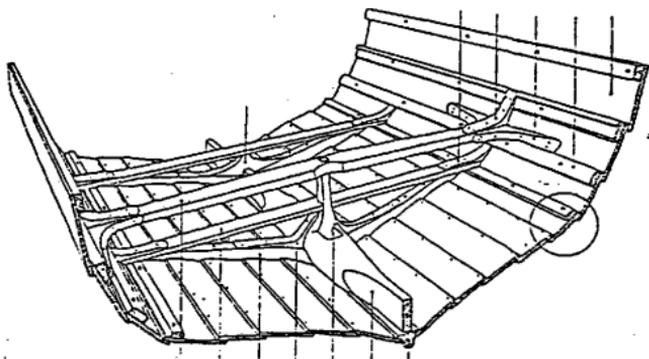
the broader, bulkier ocean-going knarr. It possesses a 1:4.2 breadth to length ratio as contrasted to the 1:6 and 1:7 for the warships. Here, the mast step is appreciably longer, well down the road to becoming a full-fledged keelson as it spans six frames (a distance of about 5.4 meters). Here, too, is evidence of a carved timber chosen for its natural vertical upshoot to lend support just in front of the mast. The smaller (13.5-meter long) cargo ship also contained a mast step whose reconstruction is somewhat unclear (ill. 55). It has been suggested that, "without the large mast partner we are familiar with from Norwegian Viking ships,"<sup>85</sup> the partner role was assumed in this case simply by a sturdier cross-beam, notched or with a hole in it to provide additional support.

Finally, as a footnote, on ship 6, which has been hypothesized as being a ferry or fishing boat, remains of a very small mast step were found. Its diminutive size is explained by the fact that the sail was not this vessel's primary means of propulsion.

In sum, the excavations of Scandinavia, though not numerous, permit some firm conclusions, due to the

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<sup>85</sup>Crumlin-Pedersen (supra n. 75) 185.



Ill. 55. Roskilde Wreck 3: Merchantman. (O. Olsen and O. Crumlin-Pedersen, Five Viking Ships from Roskilde Fjord [Copenhagen 1978] 23)

generally well-preserved state of the existing finds. The general discomfort which the Vikings felt with sailing, as reflected in their unflinching devotion to what was basically a rowing hull design, has already been mentioned. The grudging accommodations made to sailing mirror that stubbornness. The main mast cavity is extremely shallow, in contrast to the vast majority of Mediterranean examples. Missing is the logical support against the pressure of the wind-blown mast found in Mediterranean (in the form of the right angle cut to the aft side of the main cavity) and even the Celtic (in the form of the adjustment of the main socket to the forward side of the step frame) ships. Instead, there is a reliance on a vertical brace in front of the main mast cavity (Oseberg, Gokstad, Roskilde 1 and 2 ships) and/or major buttressing by the deck-level mast partner (Oseberg, Gokstad, Tune and Rong vessels). The massiveness required of the "fish" in such an arrangement substantially interfered with any cargo carrying capacity (as witnessed particularly by the Gokstad ship). Such an arrangement would have been unacceptable in the Mediterranean where commerce was a driving force in the evolution of ship technology.

## CHAPTER VII

## SUMMARY

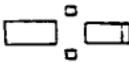
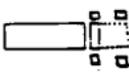
Since the first seaman converted his man-powered craft into a sailing vessel by raising a mast, shipwrights have been confronted with the technical problem of anchoring masts, rigging and sails of ever-increasing size. By the middle of the sixth century B.C., a mechanism for such support was firmly entrenched in the Mediterranean, so firmly that it would remain virtually unchanged for almost a thousand years (as indicated by excavated evidence from some twenty shipwrecks). Support of the mast was provided at three points--by stays fastened to the mast itself, by a deck-level "girdling" array, or mast partner, and by a mast step set in the bottom of the hold.

Initially, a mast step of relatively unobtrusive size, sitting atop the keel and frames at the center of the hull, was stabilized only by its own perpendicular weight and a series of underside notches designed to fit over frames. This timber increased in size in proportion to the enlargement in ship dimensions, but remained essentially static in design.

The step displayed a curious series of mortises

surrounding a main cavity. The main cavity received the foot of the mast. In early days, small, undecked merchantmen would put into safe coves by night. The main cavity was therefore arced with its right angle face to the stern to allow for the mast's unstepping and placement in a mast crutch. In time, a straight-angled main cavity remained as only a vestige of that dismantling process, since on large, decked merchant transports the mast would stay aloft throughout the sailing season.

Around the central cavity was found a complex of mortises, some square and in front of or behind the main hollow, others long and narrow and to either side of the mast footing (ill. 56). No remains of the structures which fit into these mortises have ever been discovered. Neither contemporary written accounts nor pictorial representations furnish any precise technical illumination on these support mechanisms. Yet, already by the sixth century B.C. (Bon Porté ship) this array had achieved a degree of sophistication indicative of a long-standing tradition. Given the previously-mentioned conservatism of the shipbuilding tradition, it is no less reasonable to extrapolate back in time a millennium from the Kyrenia vessel than to look forward a thousand years (to the Late Imperial Period ships). On doing this, the source descriptions equating the mast step with a  $\tau\rho\acute{\alpha}\tau\epsilon\tau\alpha$  ("table") or

	Profile	Top View
Bon Porté Ship. . . . .		
Kyrenia Ship. . . . .		
Cavalière Ship. . . . .		
Chrétienne A Ship . . . . .		
Madrague de Giens Ship. . . . .		
Île Plane à Marseille . . . . .		
Pointe de la Luque B . . . . .		
Anse Gerbal à Port Vendres Ship . . . . .		

Ill. 56. Mast Step Evolution.

tabernaculum ("tent") become interesting. For it then raises the possibility that the element so described is a direct descendant of the Egyptian "tabernacle." If so, these mortises would have received tenons from a "boxing" arrangement, intended to prevent the very movement that the stays and deck-level partner could least counteract, the forward dislodging of the mast foot.

While ship construction continued in the wholly shell-first fashion, the mast step remained simply that, a block of timber in no way acting as internal structural support. By the early centuries A.D., however, winds of change were evident in the approach to ship construction. In large measure, considerations of economy (both in labor and in materials) dictated less masterful woodworking (e.g., the less precise fit of tenon and mortise). This "sloppiness" was accompanied by, or perhaps permitted by, an increased reliance on internal structural support.

An integral element of the trend toward skeletal support was the "keelson," an internal, longitudinal spine, mirroring the exterior keel. By virtue of their identity of location, the mast step and keelson began to merge quite naturally into a single member, the product of a delicate evolutionary balance between two originally wholly distinct concepts. In contrast to the mast step, the keelson required fastening to the keel and frames to render it

effective. At the same time, with the keelson fastened by bolts for enhanced support, the need for a massive mast step, stabilized by its own weight, diminished. This symbiotic accommodation was, therefore, instrumental in the evolution of the longitudinal timber.

Quite possibly, the evolution of the keelson influenced the arrangement of the mast cavity and the supporting mortises as well. These became shallower, and less meticulous, almost contemporaneously with the hybridization of mast step and keelson. A reason for this in some instances may have been the use of the shorter lateen mast requiring less support. Perhaps a more basic reason stems from the sound bolting of the keelson/mast step to keel and frames. Earlier, with two unfastened components (mast and mast step), any instability of the one would contribute to the instability of the other. Now, with fastenings, the risk of dislodging of the step through the movement of the mast was eliminated. With less concern for keeping the mast absolutely immobile, the mast cavity and "boxing" support did not need to be quite as precise. This may be another of the numerous interdependent factors which resulted in the evolution of ship construction.

Parallel traditions have also been analyzed. Since the primary vessel of the Mediterranean tradition of the Roman, Greek and Byzantine eras was the efficient sea-going

merchant ship, the mast step timbers exhibit characteristics distinct from the Gallo-Roman tradition of inland waterway towed transport or the Scandinavian preference for longships, designed for speed but not for commerce. Accordingly, these latter forms evidence totally independent development.

Finally, definitive conclusions as to period and provenance of mast steps (and, hence, ships) are difficult to make. The former is perhaps the clearer. As a generalization, from Imperial times onward mast steps are of demonstrably smaller bulk, having assumed the keelson qualities of embryonic frame-first construction. The causes for this have been suggested earlier. Similarly, their craftsmanship has become "sloppier" (an extreme example being the Anse Gerbal a Port Vendres step with the "recycled" characteristic of refilled mortises). All of this is consistent with the overall trend toward economy in ship construction. A careful examination of steps for tool marks might shed further light on the characteristics of craftsmanship during the period in which a particular ship was built.

Provenance is a harder matter to pinpoint. The uniform nature of the "Mediterranean tradition" does not yield a clue. An analysis of wood types is equally unsatisfying, in part because of the lack of documentation. The majority

of steps appear to be of some pine or softwood species. This would be expected from what is known of wood resources in the ancient Mediterranean and the composition of other ship features. Whether the Madrague de Giens step (of oak) or the Torre Sgaratta artemon step (of elm) employed other wood types for strength, or as a result of availability, is unclear. Better wood analysis of steps, as of all ship timbers, might provide a key to the locales of construction.

In summary, the mast step or keelson, by virtue of its very size, will usually survive amid ancient shipwreck remains. With proper recordation, such easily identifiable timbers should come to be one of the tell-tale indicators in tracing the history of ancient ship construction.

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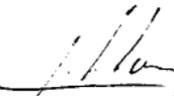
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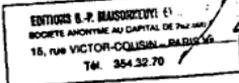
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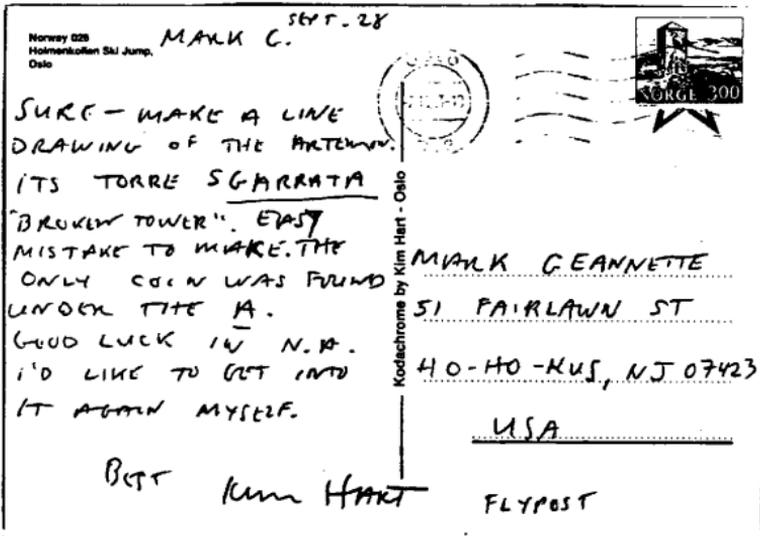
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Ho-Ho-Kus, New Jersey 07423

Dear Mark:

This will confirm my approval of your use of my keel and keelson drawings which were published in the International Journal of Nautical Archaeology 11 1982 in my article "The Reconstruction of the 11th Century Serce Liman Vessel." I understand that you intend to use these illustrations in your master's thesis.

Sincerely,

Handwritten signature of J. Richard Steffy in cursive.

J. Richard Steffy  
Assistant Professor  
of Anthropology

JRS:co

**FEDERICO FOERSTER**

(FEDERICO FOERSTER LAURES)

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El Departamento de Correos y Telecomunicaciones de España

*Barcelona*, 17, 7th. November 1985  
CONSEJO DE CIENCO, 222

Mr.  
 Mark Alan Geannette  
 51 Fairlawn Street  
 Ho-Ho-Kus  
 New Jersey 07423 USA  
 EE.UU. America del Norte

Dear Sir,

It is a pleasure for me to give you the permission to reproduce the diagrams referring to the mast shoes, as found at the wreck named Cap del Volt, whether these have been published or not in Vida Submarina.

Yours faithfully



TODAS LAS OPERTAS SE ENTIENDEN SIN COMPROMISO



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Mr. Mark Geannette  
51 Fairlawn Street  
Ho-Ho-Kus, New Jersey  
07423 USA

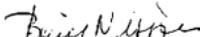
Stockholm, October 31, 1983

Dear Mr. Geannette:

Thank you for your letter of 10 October. It is ok for you to use the two illustrations you mention from SHIPS OF THE PHAROAHS by Björn Landström (pages 47 and 48). Please give full credit to author and work in your thesis.

Sorry for the delay in answering. Please note our name and address.

Yours sincerely,

  
Britt Nilsson



THE DANISH NATIONAL MUSEUM  
THE DIRECTOR

Copenhagen 10 Oct., 1983

Dear Mr. Mark Geanette,

Thank you for your letter of 20 September.  
You are - of course - welcome to use any illustration from "Five Viking Ships" in your thesis. And I wish you the best of luck for your work.

Yours sincerely,

A handwritten signature in black ink, appearing to read 'Olaf Olsen', written in a cursive style.

Olaf Olsen

51 Fairlawn Street  
 Ho-Ho-Kus, New Jersey 07423  
 14 November 1983

Ms. Mary Doherty  
 Photograph Library  
 Metropolitan Museum of Art  
 5th Avenue at 82nd Street  
 New York, New York 10028

Dear Ms. Doherty:

As I indicated to you by phone today, I have just completed by thesis for a Master of Arts degree in nautical archaeology at Texas A; M University. I would like to include a reproduction of Plate 85 of H. E. Winlock, *Models of Daily Life in Ancient Egypt* (1955) which I understand Harvard University Press printed for the Museum. I therefore respectfully request permission for such use. Proper credit will, of course, be given in the text of the thesis.

Thank you for your kind assistance.

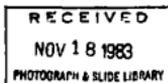
Nov. 21, 1983

Permission granted.

*Mary F. Doherty*

Photograph Library

Very truly yours,  
 Mark Geannette



## VITA

Mark Alan Geannette received a Bachelor of Arts degree with a major in Classics from Wesleyan University in 1970 and a Doctor of Law degree from Cornell Law School in 1973. He was a Deputy Attorney General for the State of New Jersey from 1974 to 1978 and since that time has been engaged in the corporate and private practice of law. He resides with his wife and son at 51 Fairlawn Street, Ho-Ho-Kus, New Jersey 07423.

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